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POWER

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Fire Often, Fire Light

By R. T. Strohm

IF your boss begins complaining
That his power bill is draining
Every cent he has remaining
In a fashion expedite,
Take the hint that he's conveying
And remember that he's paying
You for working, not for playing—
Fire often, fire light.

IF the chimney belches gases
That deposit sooty masses
On the pretty girl that passes
In her dainty dress of white,
Don't assume a manner humble
And attempt to smirk and mumble
Your excuses. Take a tumble—
Fire often, fire light.

DON'T get hot beneath the collar
If the boss puts up the holler
That you lose from every dollar
Half its purchase power, quite.
Common Sense, the great physician,
Will prescribe for your condition
Just this simple admonition—
Fire often, fire light.

QUIT your dozing and your dreaming;
While you fire, get to scheming
How to raise the rate of steaming
To an economic height.
For the boss will be your debtor
If you follow to the letter
This advice—there's nothing better—
Fire often, fire light.

Bakersfield, Calif., Steam Power Plant

SYNOPSIS—Construction of this plant was begun in 1910, and was in progress intermittently until the fall of 1913. The demand for electrical energy was so rapid that the installation of additional equipment kept the plant in an unfinished state during practically all of that time, thus rendering its operation somewhat difficult. Notwithstanding these drawbacks, however, the operating record of the plant is excellent. There are three turbo-generators, of 2500-, 6250-, 7800-kv.a. capacity. Steam is supplied by 12 water-tube boilers, a total of 6048 hp. Water for condensing purposes is taken from an irrigation canal, 75 ft. west of the plant. The auxiliaries, including exciters, air and circulating pumps, boiler feed and general-service pumps, are on the ground floor. The electrical equipment is on the three floors of the lean-to on the west side of the turbine room.

The growth of the San Joaquin Light & Power Corporation has been rapid. In 1909, the total generating capacity was approximately 4500 kv.a., then grew to 40,000 kv.a. in 1913, at which time there was an additional 6000 kv.a. capacity on order or being installed.

In 1910 the property of the Power Transit & Light Co., of Bakersfield, Calif., was acquired. This gave an additional source of electrical supply in a hydro-electric plant on the Kern River, consisting of three 450-kv.a. horizontal units which had been installed some 15 years before, and which were wholly inadequate for the demands required. Although the acquisition of this plant made a valuable addition to the generating capacity of the system, it was realized that it was not capable of meeting the overloaded conditions locally, nor was it of material assistance for peak conditions over the entire southern part of the system. Therefore, it was decided that the remedy lay in building a plant which would ultimately become the principal reserve steam plant of the southern part of the system. With this in mind, Bakersfield, Calif., was selected. The site fixed upon was adjacent to an irrigation canal of the Kern Island Canal Co., this being the only reliable source of water supply

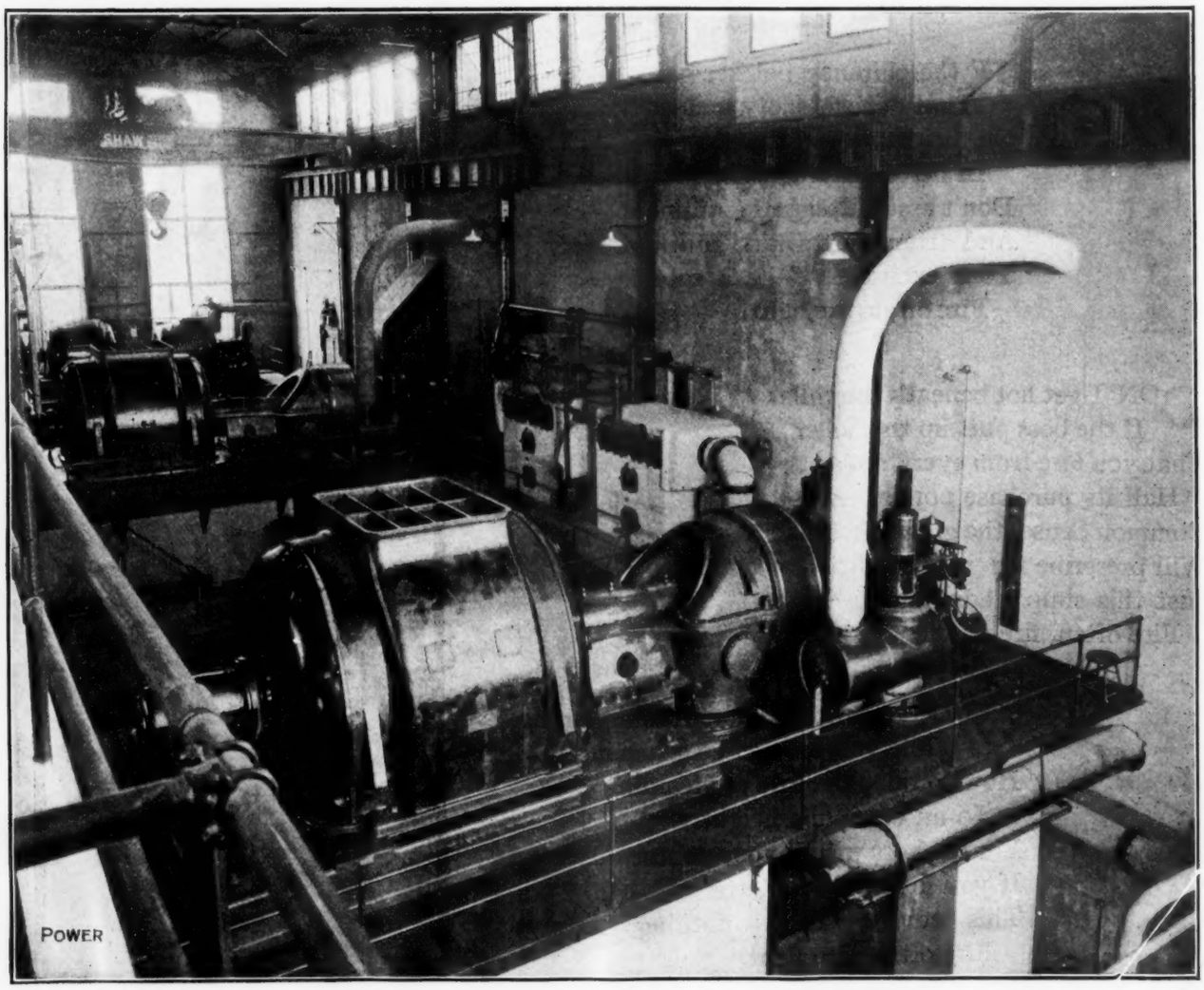

FIG. 1. GENERAL VIEW OF THE TURBINE ROOM FROM THE GALLERY

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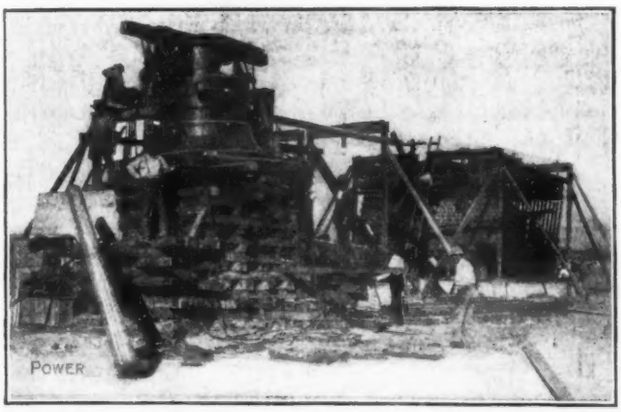


FIG. 2. ERECTING THE TEMPORARY GENERATING UNIT AND BOILERS

having sufficient water for condensing purposes. The power plant is built on a 15-acre plot east of this canal and about 2000 ft. north of the main San Joaquin Valley branch of the Southern Pacific Ry.

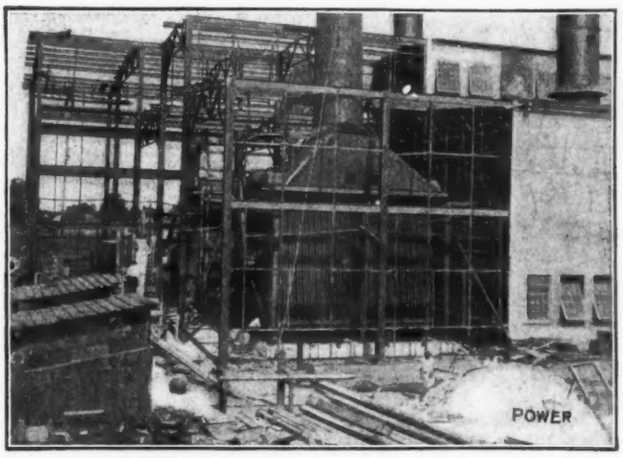


FIG. 3. EXTENDING THE PLANT WHILE ERECTING ADDITIONAL UNITS

As originally designed, the plant was to contain two 2500-kv.a. turbo-generators; the first to be placed at once and the other later. Before the first unit could be procured, however, it became necessary, because of the urgent demand for energy, to secure a temporary generator; a 750-kv.a. vertical unit was the largest available; four 304-hp. boilers were also secured. With this equipment as a nucleus, a temporary plant was constructed and put in operation 49 days after this equipment reached the grounds and some time before even the steel for the main building had been delivered. Fig. 2 shows the apparatus being installed, no evidence of a building being seen. When the temporary plant was first started, the boilers were without shelter and the turbine, the switchboard and the exciter were inclosed in a temporary shed for protection while the permanent building was being erected.

The power-plant building is of fireproof construction,

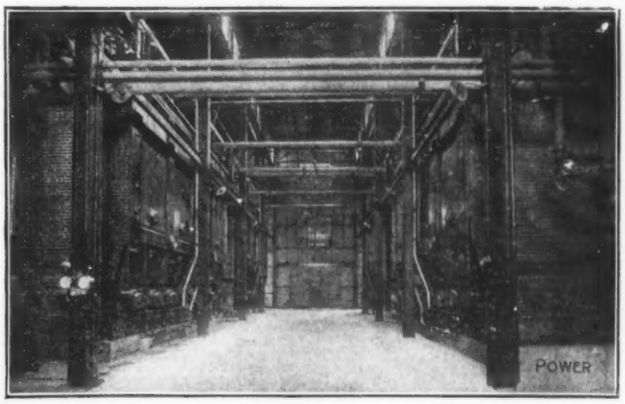


FIG. 5. BOILER ROOM CONTAINING 12 WATER-TUBE BOILERS

with self-supporting steel frame and concrete walls, partitions and roofs, reinforced with Hy-rib steel. All the floors are of concrete; those in the galleries being reinforced with wire mesh. The turbine room is approximately 40 ft. wide by 145 ft. long. Adjacent to this on the west is the electrical lean-to, a structure 20 ft. wide and 145 ft. long; the boiler room is 81 ft. 8 in. wide by 125 ft. long. The lean-to is arranged in three levels. The ground floor houses the transformers, generator and low-tension transformer switches, motor-generator sets, 2300-volt altenating-current busbars, oil switches for local service and switchboard for control of the auxiliaries. The first gallery or operating floor level carries the main switchboard, 10,000-volt alternating-current busbars and oil switches. From this gallery platforms attached to the operating platforms around the generating units connect on the east side with the platform around the heaters,

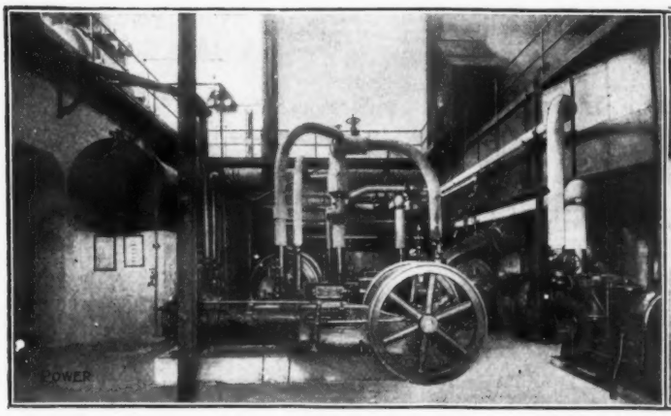


FIG. 4. CONDENSER EQUIPMENT FOR THE 2500-KV.-A. UNIT

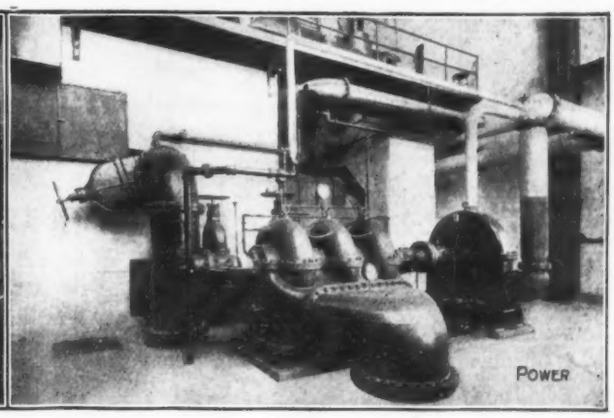


FIG. 6. TRI-ROTOR, TURBINE CENTRIFUGAL PUMP

thus all units on this level are accessible from any part of the power house. The third floor contains the 60,000-volt alternating-current busbars and oil switches. The outgoing and incoming feeders go through the west side of the lean-to.

Turbo-Generators

Owing to the rapid growth of the company's business, the original plan of installing two 2500-kv.a. units was abandoned, and in place of the second 2500-kv.a. machine a 6250-kv.a. unit was selected. The third unit is of 7800-kv.a. capacity. The first temporary unit was put in operation early in 1911; the second in November of the same year, and the third unit late in 1913.

Although the capacity of the second unit is more than twice that of the one contemplated when the plant was designed, it was not necessary to make any changes in the turbine room to accommodate this larger unit; in fact, the only deviation from the original plan was in building a 20x20-ft. addition to the electrical lean-to to house the transformers, and when the third unit was installed it was possible to make the turbine room symmetrical. Although the capacity of the third unit is 1550 kv.a. greater than that of the second, it occupies practically the same amount of floor space, due to the modification in design of the turbo-generators during even the short interval between the dates on which these two machines were purchased.

To house the third unit, it was necessary to extend the turbine room and electrical lean-to south about 60 ft., and the boiler-room about 40 ft. to the full width and height of the original structure, Fig. 3. The plant now has a capacity of 16,550 kv.a. in three units. The general view of the operating floor of the turbine room as seen from the south end of the 10,000-volt gallery is shown in Fig. 1. Fig. 7 is a view of the electrical lean-to looking west from a position between Nos. 1 and 2 turbines. In the foreground to the left, adjacent to the foundation of No. 2 generator, is the 75-kw. turbo-driven, 125-volt exciter unit. Between the two motor-generator sets is a 100-kw. exciter driven by an induction motor. These units also supply energy for operating a 35-ton electric traveling crane, a portable motor-driven air compressor and for emergency lighting.

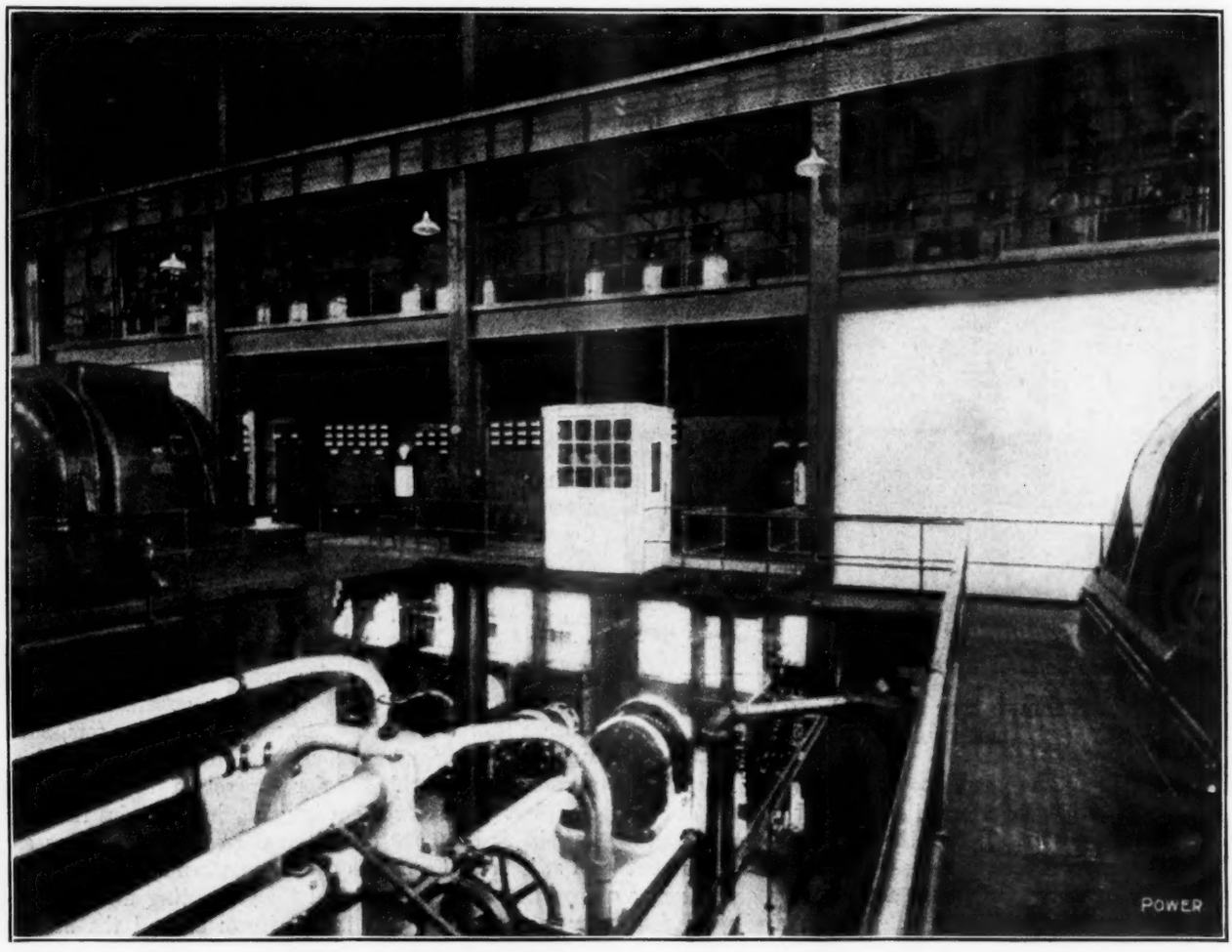


Fig. 7. View of the Galleries and Exciter Units

Condensers

A separate condensing outfit is furnished for each main turbine. That for the 2500-kv.a. unit contains 6000 sq.ft. of cooling surface in ¾-in. brass tubes, or 2.4 sq.ft. of surface per kv.a. Each of the other two condensers has 15,000 sq.ft. of cooling surface, the tubes in No. 2 condenser being ¾ in. and in No. 3 condenser 1 in. In the No. 2

condenser the number of square feet of cooling surface is the same as in No. 1. No. 3 unit contains 1.9 sq.ft. of surface per kv.a. capacity.

There are three condenser circulating pumps, two of the single-stage centrifugal type, driven by horizontal compound, noncondensing engines, having 9 and 17 by 12-in. cylinders. The last circulating pump installed is of the multi-rotor centrifugal type, driven by a directly connected noncondensing steam turbine.

Each of the engine-driven units has a capacity of 10,000 gal. per minute; and the turbo-driven unit 15,000 gal. The capacities of these pumps are such that either of the engine-driven units will furnish sufficient water for the two smaller turbines, and one of these, in conjunction with the turbine-driven pump, will furnish water for all three turbines. The piping from the pumps to the condensers is designed for operating the station in this manner. Fig. 4 shows the arrangement of the condenser for the 2500-kv.a. turbine, the rotative dry-vacuum pump being in the foreground and the engine-driven circulating pumps at the rear. The 75-kw. turbo-exciter set is to the right of the air pump. The steel-plate duct supplies air for the 6250 kv.a. generator.

The tri-rotor turbine-driven centrifugal pump for the 7800 kv.a. turbine and a portion of the condenser for this unit is shown in Fig. 6. The duct in the upper left foreground supplies air for the No. 3 unit. A 6 and 7¼ by 6 in. direct-acting piston pump removes the condensate from No. 1 condenser. On unit No. 2 there are two 3-in. centrifugal pumps, one turbine and one motor driven. One 4-in. turbine-driven circulating pump is used in conjunction with No. 3 condenser. Air is removed from No. 1 condenser by a 10 and 18 by 18-in. tandem center-crank rotative dry-vacuum pump. Each of the other two condensers is equipped with a 12 and 30 by 18-in. air pump of the same type.

Condensing water is taken from the irrigation canal, which is about 75 ft. west of the plant, and after passing through the condensers is returned to the ditch at a point south of the plant and sufficiently far from the intake to prevent heating the supply water. The intake from the canal has duplicate screen chambers, the area of which is much in excess of the two 26-in. cast-iron pipe lines which connect with the suction of the circulating pumps.

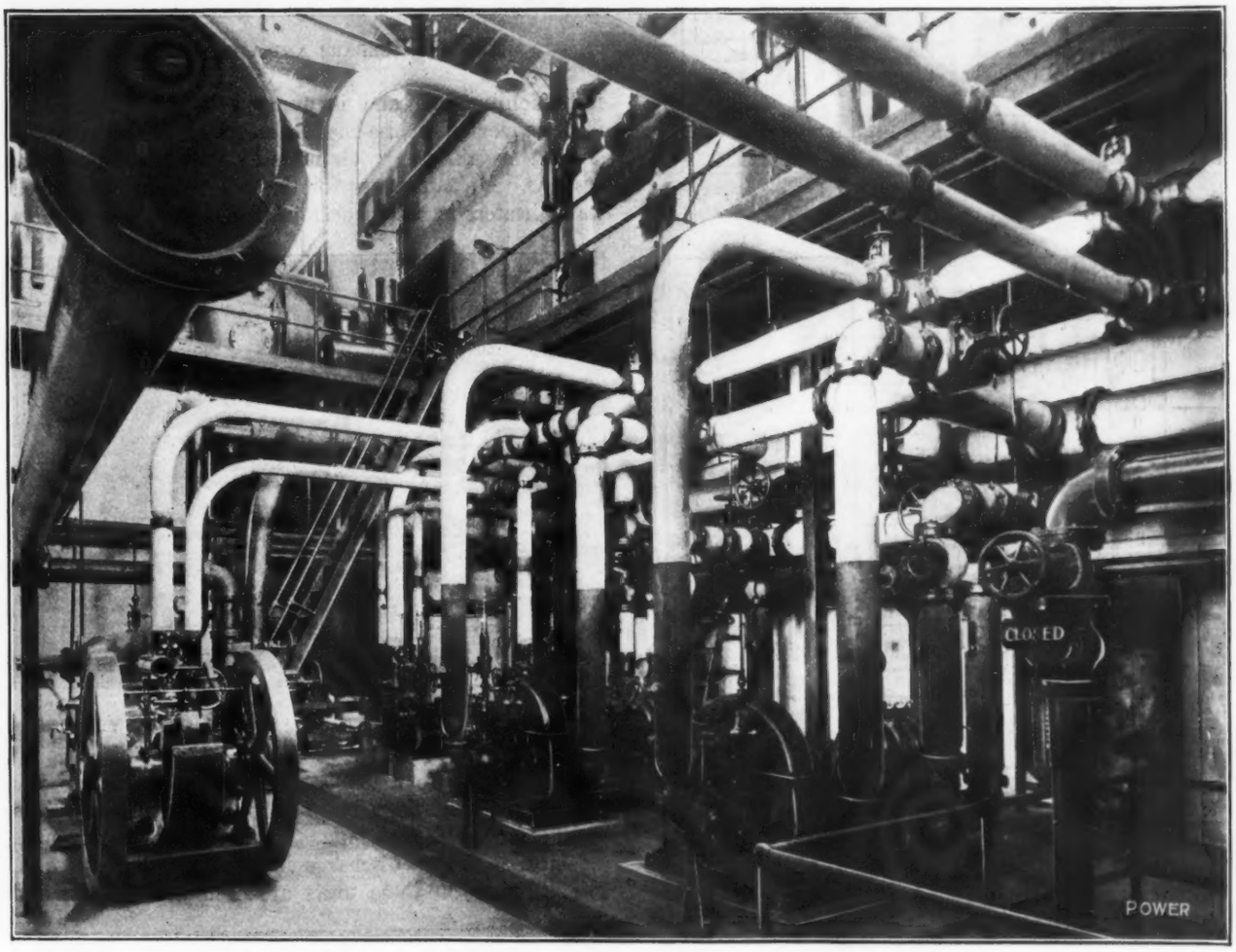


FIG. 8. TURBINE-DRIVEN BOILER-FEED PUMPS AND SERVICE PUMPS

BOILERS

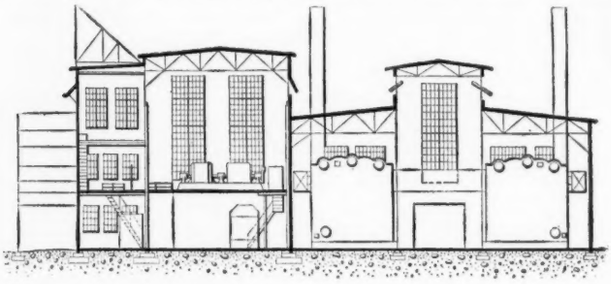
The steam generators consist of 12 water-tube boilers designed for 200 lb. working pressure, Fig. 5; four are rated at 304 hp. each, and the remaining eight are of 604 hp. capacity each. The latter are equipped with "U"-type superheaters, which superheat the steam from 100 to 125 deg. All of the boiler furnaces burn crude oil.

Oil is delivered to the plant on a spur of the Southern Pacific Ry., and is stored in a 2500-bbl. capacity steel tank placed conveniently for receiving oil by gravity from the cars. The tank is buried to within 1 ft. of its top and is

protected by a roof. Provision is made for heating the oil in cold weather and also for fire suppression. The oil is heated and delivered to the burners by two fuel-oil sets, each consisting of two 5¼ and 4¾ by 5 in. fuel-oil pumps; one vertical exhaust-steam oil heater and one vertical multi-coil, high-pressure oil heater. These heaters maintain the temperature of the oil fed to the burners at approximately 180 deg. under the most severe operating conditions.

Boiler-Feed Supply

Water for the boilers is obtained from two 90-ft. deep wells by vertical centrifugal pumps directly connected to



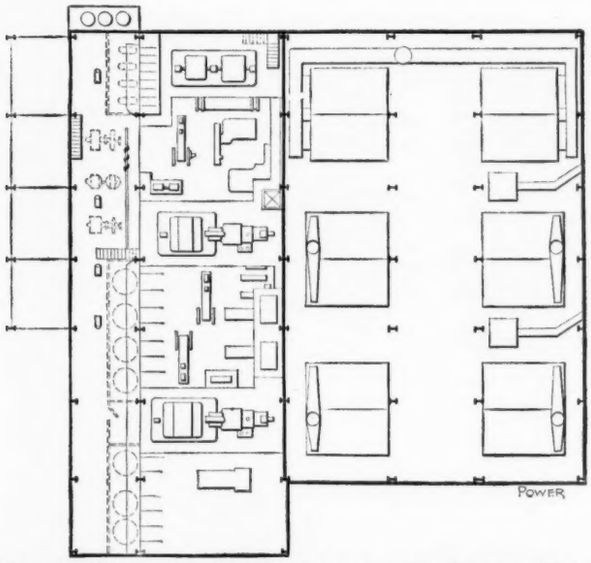


Fig. 9. Plan and Elevation of the Power Plant

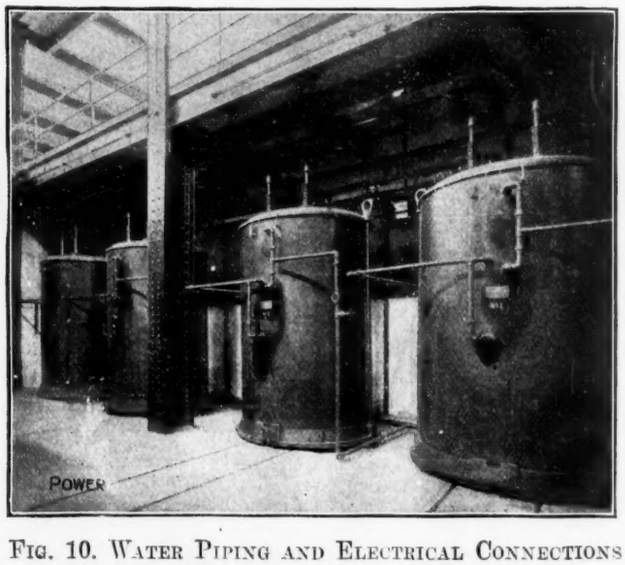


Fig. 10. Water Piping and Electrical Connections of the 2100-Kv.-A Transformers

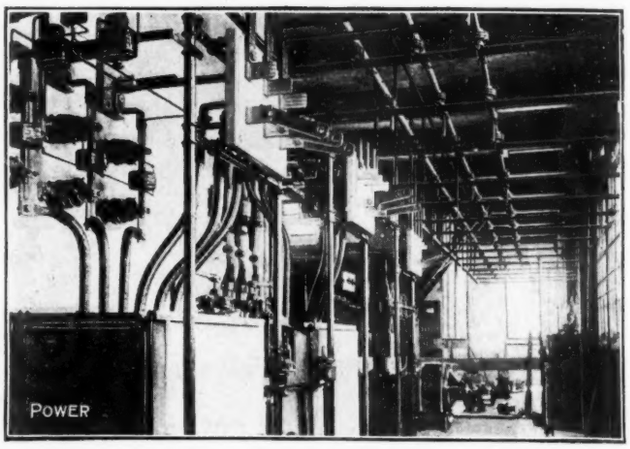


Fig. 11. Busbars and Oil Switches

induction motors, and is pumped to a 2500-gal. steel tank supported on the roof members of the boiler house. From this tank the water flows by gravity to the piping systems. Makeup water for the two 4000-hp. open feedwater heaters is obtained from this tank. These heaters

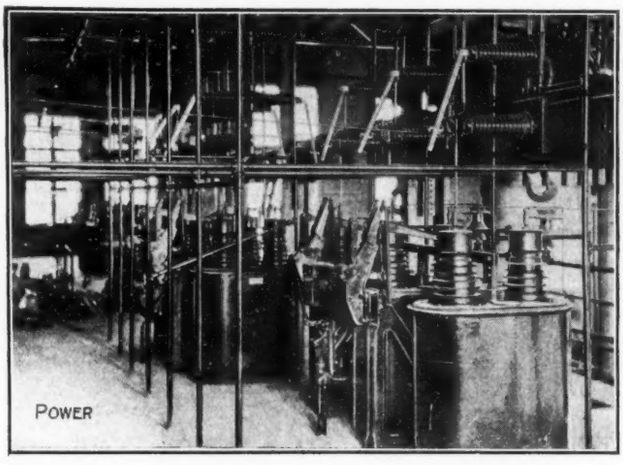


Fig. 12. 10,000-Volt Busses and Oil Switches

raise the water to a temperature of approximately 200 deg., which then flows by gravity to two turbine-driven multi-stage boiler-feed pumps, each of 600 gal. per min. capacity, against a discharge head of 250 lb. per sq.in. The turbines on these units are each of 137 hp., and

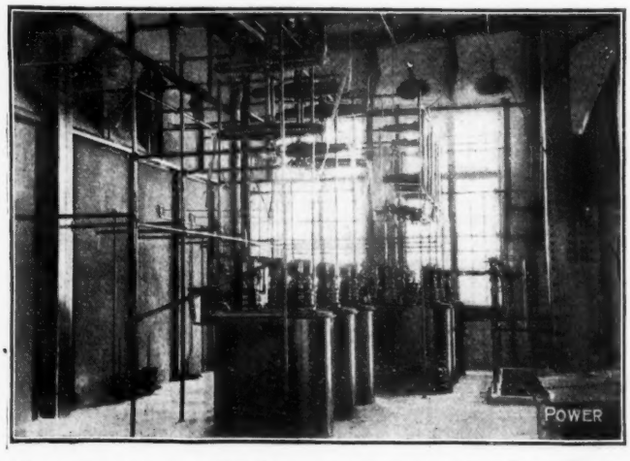


Fig. 13. The 60,000-Volt Busses and Oil Switches

exhaust into the open heaters. In addition, there are also two 9 and 5 by 10-in. plunger-type pressure pumps for filling and cleaning boilers and for miscellaneous purposes.

In Fig. 8 can be seen the turbine-driven boiler feed and the general service pumps. Fig. 3 shows the two feed-water heaters on the turbine-operating floor level.

Piping

The main steam piping is designed for 200 lb. working pressure and 100 deg. superheat. The 6-in. pipes from each boiler connect to a main 10-in. header from which a 10-in. branch line goes to each of the two larger turbines and an 8-in. line to the small one. All joints are of the van-stone type with steel flanges, and all the fittings and valves are of steel. Each boiler is protected by an automatic nonreturn stop and check valve, and the lead to each turbine has an emergency remote-control valve permitting any one of the units being shut off from a distance in case of an accident to the turbine or to the steam

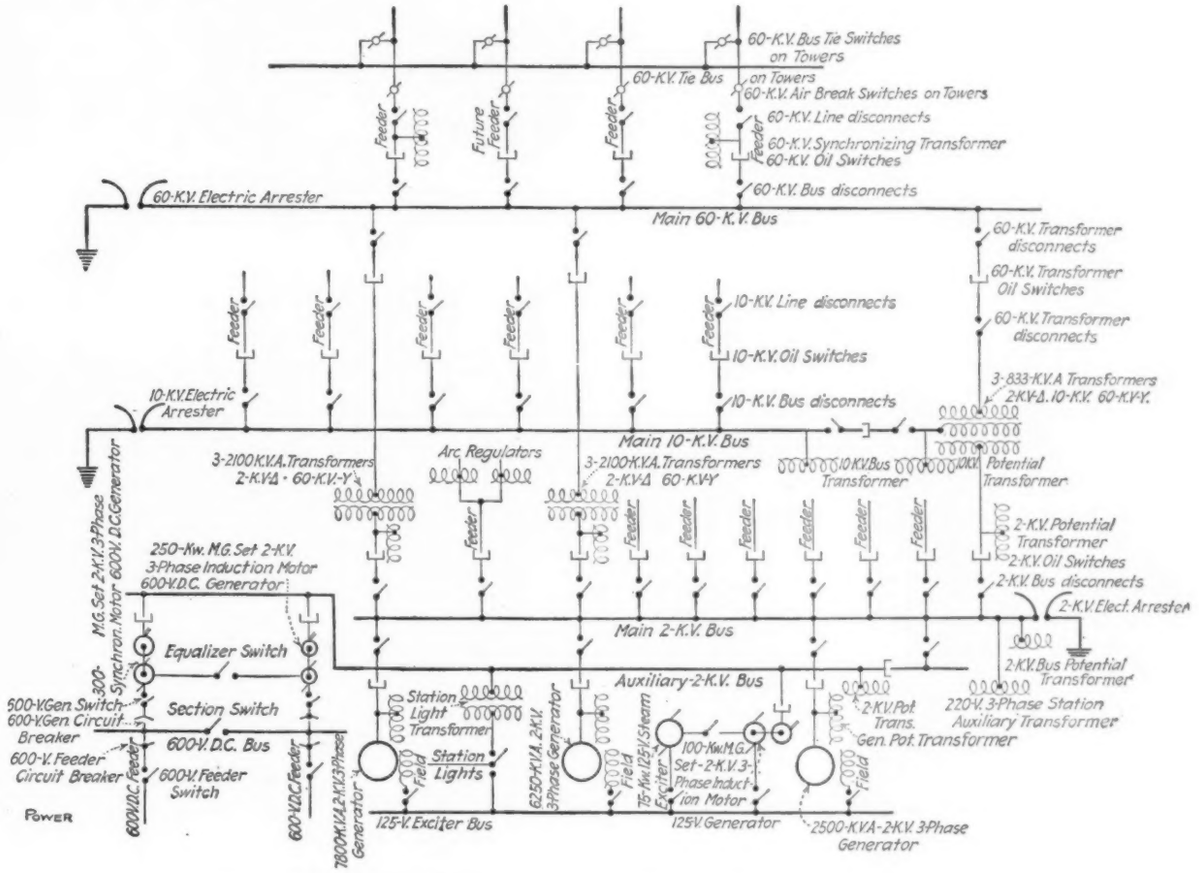


Fig. 14. Wiring Diagram of the Plant, Showing Connections

PRINCIPAL EQUIPMENT OF THE BAKERSFIELD STEAM-TURBINE POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-gen.....	Curtis horizontal..	2500 kv.a.....	Main generating unit....	190 lb. steam, 100 deg. superheat, 28" vac., 1800 r.p.m.	General Electric Co.
1	Turbo-gen.....	Allis-Parsons.....	6250 kv.a.....	Main generating unit.....	190 lb. steam, 100 deg. superheat, 28" vac., 1800 r.p.m.	Allis-Chalmers Co.
1	Turbo-gen.....	Allis-Parsons.....	7800 kv.a.....	Main generating unit....	190 lb. steam, 100 deg. superheat, 28" vac., 1800 r.p.m.	Allis-Chalmers Co.
1	Turbo-gen.....	Curtis, single-stage.	75 kw.....	Exciter and emergency station lighting.....	190 lb. steam, 125 volt	General Electric Co.
1	Motor-gen.....	Induction, direct current.....	100 kw.....	Exciter and emergency station lighting.....	Three-phase, 60 cycle	General Electric Co.
2	Engines.....	Reciprocating.....	9x17x12.....	Driving circulating pumps	Non-condensing	Harrisburg Foundry & Mch. Co.
2	Pumps.....	Centrifugal, single-stage.....	10,000 gal. per min.....	Circulating pump.....	.....	Alberger Pump & Condenser Co.
1	Turbine.....	Single-stage.....	.....	Driving circulating pump	Non-condensing	Alberger Pump & Condenser Co.
1	Pump.....	Centrifugal, multiple motor.....	15,000 gal. per min.....	Circulating pump.....	.....	Alberger Pump & Condenser Co.
4	Boilers.....	B. & W.....	304 hp.....	Steam generators.....	200 lb. pressure, two burn oil, two burn natural gas	Babcock & Wilcox
8	Boilers.....	Stirling U superheaters.....	604 hp.....	Steam generators.....	200 lb. pressure, burning crude oil	Babcock & Wilcox
2	Heaters.....	Open.....	4000 hp.....	Heating boiler feed water	Exhaust steam from auxiliaries	Harrison Safety Boiler Works
2	Turbines.....	Single-stage.....	137 hp.....	Driving boiler feed pumps	200 lb. steam pressure	Alberger Pump & Condenser Co.
2	Pumps.....	Multi-stage cen....	600 gal. cap...	Boiler feed pumps.....	Turbine driven	Alberger Pump & Condenser Co.
2	Pumps.....	Plunger.....	9x5x10-in.....	Miscellaneous.....	Steam driven	Henry R. Worthington
2	Pumps.....	Plunger.....	5¼x4½x5-in.....	Pumping fuel oil.....	Steam driven	Platt Iron Works
1	Pumps.....	Rotating.....	10x18x18-in...	No. 1 condenser.....	Steam driven	Alberger Pump & Condenser Co.
2	Pumps.....	Rotating.....	12x30x18.....	Nos. 2 and 3 condensers..	Steam driven	Alberger Pump & Condenser Co.
1	Condenser.....	Surface.....	6000 sq.ft. surface.....	No. 1 turbine.....	28-29-in. vacuum	Alberger Pump & Condenser Co.
2	Condensers.....	Surface.....	15,000 sq.ft. surface.....	Nos. 2 and 3 turbines....	28-29-in. vacuum	Alberger Pump & Condenser Co.
8	Valves.....	Non-return.....	6-in.....	Steam pipes from boilers..	Automatic	Schutte & Koerting Co.
3	Valves.....	Emergency.....	1 8-in. 2 10-in.	Steam lines to turbines..	Remote control	Schutte & Koerting Co.
	Valves.....	Several.....	Various.....	Miscellaneous.....	.....	Crane Co.
4	Transformers...	Water cooled.....	833 kv.a.....	Transforming for line.....	2300-11,000, 40,000-60,000 Y volts	General Electric Co.
4	Transformers...	Water cooled.....	2100 kv.a.....	Transforming for line.....	2300-40,000, 60,000 Y volts	Allis-Chalmers Co.
1	Motor-generator	Direct current.....	300 kw.....	Railway work.....	.....	General Electric Co.
1	Motor-generator	Direct current.....	225 kw.....	Railway work.....	.....	General Electric Co.

line supplying it. Expansion is taken care of by means of 90-deg. bends in the leads from each boiler and by two U-bends in the main header. All steam and exhaust lines, feed-water heaters, traps, etc., are insulated with 85 per cent. magnesia covering, the thickness varying with the service required.

Electrical Equipment

The electrical-control equipment and busses are directly to the west of the turbine room. There are four 833-kv.a. water-cooled transformers, and in Fig. 10 are shown the water piping and electrical connections for four 2100-kv.a. transformers. There are also on this level a 225-kw. and a 300-kw. motor-generator set, as well as the 2300-volt busbars and oil switches and switchboard for the control of the auxiliaries, Fig. 11.

The main switchboard, on the turbine-operating floor level, is shown in Fig. 7. Here are also the 10,000-volt busses and oil switches, Fig. 12. Both the 10,000- and 60,000-volt busses are of copper tubing; the 2300-volt busses are of copper bar. There are electrolytic lightning arresters for each of the three operating voltages connected to extensions of the several busses. The 60,000-volt bus and oil switches are on the third floor, Fig. 13.

Transmission Lines

The Bakersfield station was designed to eventually serve as the main steam reserve to the enlarged transmission system, and operate in parallel with it at 60,000 volts as well as supplement the output of the Kern Cañon plant; also to operate in parallel with it and the original transmission line at 11,000 volts. Furthermore, under certain conditions it was to operate as a rotary condenser station to correct the power factor of the transmission system as well as to serve as a substation supplying local service at 2300 volts, series alternating municipal lighting, and direct current at 600 volts for traction and motor service, all of which made the electrical layout of the plant unusually complicated.

To avoid duplication of equipment and at the same time to provide for the several voltages with which it was necessary to parallel and to supply the design, the first complement of transformers was a departure from standard practice. Each transformer, of 833-kv.a. capacity, has the usual primary coils for 60,000 volts and two secondary windings, one for 2300 and one for 11,000 volts, designed to deliver the full rated capacity of the transformers at their respective voltages. The seven 2100-kv.a. water-cooled transformers are wound for 23,000, 40,000 and 60,000 volts.

Electric current is furnished to Bakersfield from hydro-electric plants in the central part of the San Joaquin valley, about 100 miles north of Bakersfield, and from the Kern Cañon plant, about 20 miles east of Bakersfield.

Around the time that the first unit was started, the west side line of this transmission system had been completed. It has since been supplemented by a similarly constructed line on the east side and the steam plant at Bakersfield now stands at the south end of this loop. A wiring diagram of the plant, showing the method and plan of connection, is shown in Fig. 14.

New Water-Tube Boiler

The cross-drum, water-tube boiler, shown in Figs. 1, 2 and 3, embodies novel features worthy of noting. The furnace, which may be any height, is roofed over by water tubes, incased in refractory tile, thus forming practically a smokeless furnace for long-flame coal. The main bank of tubes is covered from end to end on the top row, and vertical side baffles are provided and perforated, the products of combustion finding outlet through the perforations.

A supplementary combustion chamber above the bottom row of tubes is created by omitting a number of tubes in the vertical rows. The products of combustion in entering this chamber are compelled to mix and blend, thus aiding in securing complete combustion prior to the gases coming in contact with the relatively colder boiler heating surface. The gases on entering this chamber are completely surrounded (top, sides and ends) by the heat-absorbing surfaces of the boiler. The gases then flow laterally toward the vertical baffles on the sides, and from thence flow upward into the upper chamber from which they pass to the chimney. The aim of the designer has been to eliminate brickwork outside the furnace proper, thus reducing the first cost, cost of upkeep, as well as the usual heat losses chargeable to radiation and infiltration of air.

Above the lower row of tubes the brickwork does not extend, as steel casing is used on sides and top. Inasmuch as the temperatures of the gases are quite low at such points, the cost of insulation for the steel casing is low and heat losses may be easily avoided. It will be noted that as the flow of the gases in the main bank of tubes is laterally, the gases are distributed more equally to the tubes, thus avoiding localizing the high temperature gases on the ends of the tubes.

By using 3 or 3½-in. tubes the gas passages between the tubes may be reduced to 2 in., which saves in floor space and increases the efficiency, and still it is possible to have low temperatures at the side baffles. There can be no infiltration of cold air (outside the furnace) to the high-temperature zone. In the upper chamber, 4-in. tubes connect the front header to the steam and water drum and at the rear similar tubes connect the drum to the top of the rear header.

Another horizontal row of tubes, which is out of the path of the gases, connects the front header to the rear one, and inasmuch as this row of tubes is "neutral" as respects absorbing heat, a return flow of water from the front to rear header will take place in these tubes, thus relieving the upper row, and the drum from duty to a large extent.

The headers or water-legs may be of the usual stay-bolted design, or of the separate design to embrace one or two vertical rows of tubes. As the temperatures in the upper chamber are very low the cross drum is not exposed to high heat and there its life is prolonged.

The soot is easily reached either through the side doors or by passages provided in the headers. The main bank of tubes is readily accessible for repairs or inspection

through the supplementary combustion chamber, and from the sides and top by removal of the tile or baffle. The side baffles are suspended from the top tube in the outside row, and are readily removed for inspection. Superheaters may be easily installed by providing an opening in the rear header through which the piping can be readily inserted.

This design, while appropriate for any service, is specially adapted for city use, owing to the small floor space required, and, of course, its head room is no greater than with other types.

Fig. 3 shows a modification of the design for small units in which the tile on one side is protected by vertical water tubes. The "double-pass" design is for larger units, such as are now required for larger plants. The designer and patentee of the boiler is T. T. Parker, of New York City.

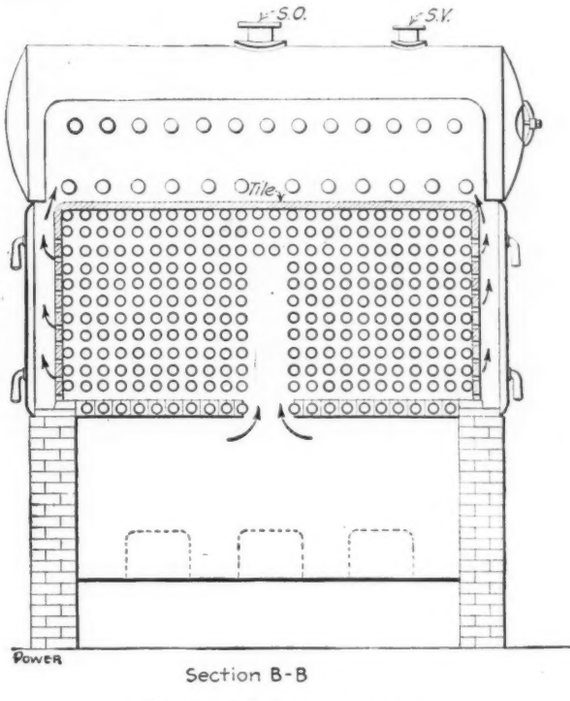


Fig. 1. Transverse section.

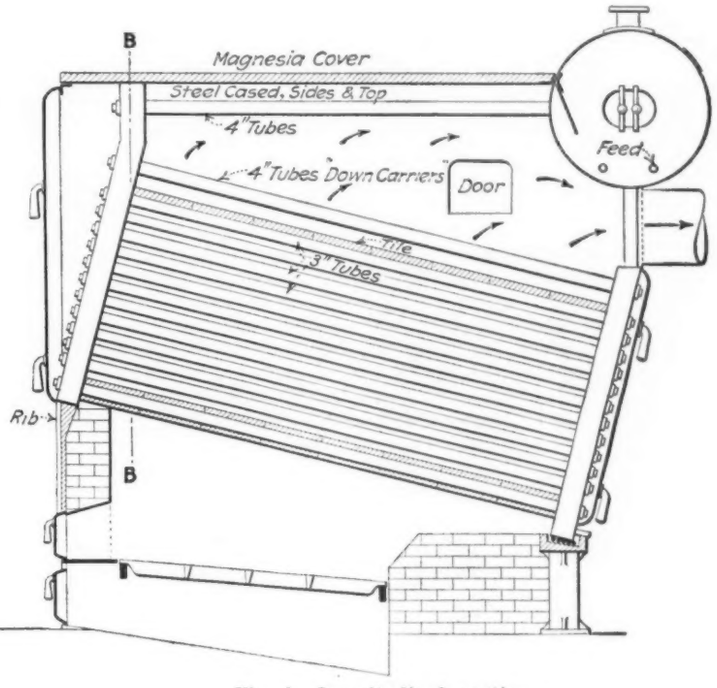


Fig. 2. Longitudinal section.

DOUBLE-PASS TYPE OF THE NEW WATER-TUBE BOILER

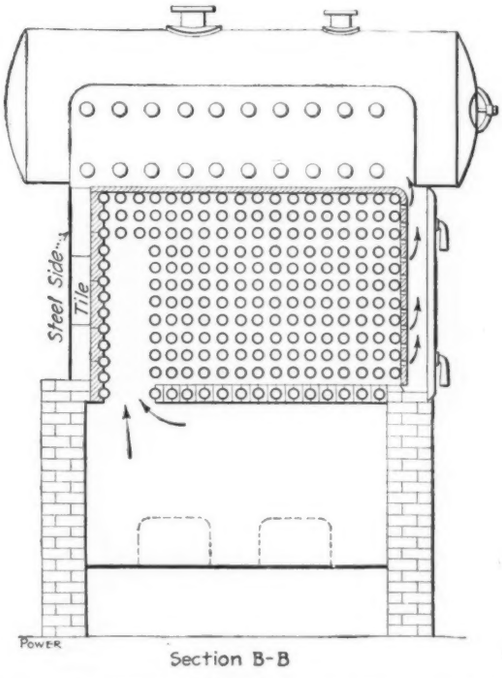


FIG. 3. TRANSVERSE SECTION OF THE SINGLE-PASS BOILER

Keystone Stoker

Something new in stokers, Fig. 1, is being put out by the Keystone Stoker Co., of 141 Milk St., Boston, Mass. As may be seen from the illustrations, it is of the chain-grate type, but differs radically from others, in that the grate is made up of disks mounted on bars like rings on a cane. The whole chain is made up of these disks which move along toward the bridge-wall, rotating on their axes as they carry the fuel along. This feature is really the most important one in the design of the stoker. By reason of the revolving disks, a clinker that may form does not have an opportunity to stick to the disks and tends to become broken so that there is no serious plugging of the air spaces. Further, it will be seen that there is not one surface only on the fire side of the grate all the time, as with other chain grate stokers. As the disks revolve they get away from the fire or fuel-bed side and come in contact with the air-pressure side for their entire surface many times during their travel from the front to the bridge wall.

As the fuel bed is in more or less of a free state, it is not necessary to use very high draft pressure. The air velocity through the fuel bed should be quite uniform on this account, and therefore tends to burn the fuel evenly, preventing the formation of holes through which air may rush and not become mingled with the gases,

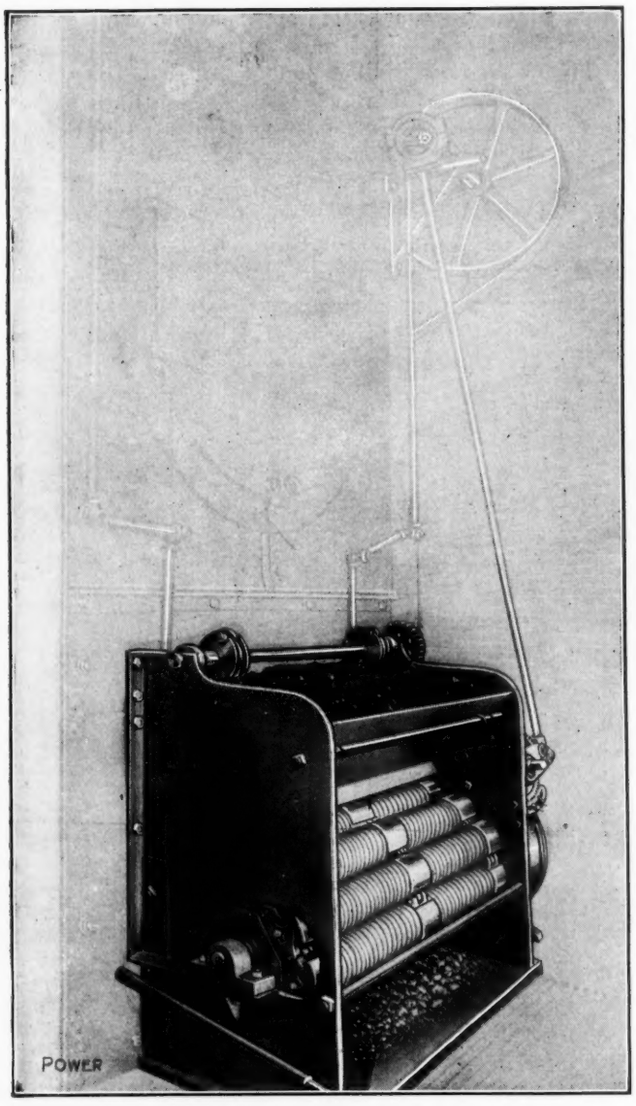


FIG. 1. THE KEYSTONE STOKER

thereby considerably increasing the free oxygen in the flue gases and also reducing the CO_2.

The number of revolutions that the bar carrying the disk will make in its travel through the fire is adjustable.

Another advantage of the stoker is the ease with which a new bar of disks may be inserted during the regular operation of the stoker. This is shown in Fig. 2, in which the operator has the stoker momentarily shut down, while with a pinch bar, he takes out a section of disks to be replaced by another section kept on hand for such purposes.

As will be seen from Fig. 3, a water box is used in the bridge wall to protect the masonry and prevent it from getting so hot as to melt away. These water boxes are not connected in any way with the boiler and cannot become a source of danger, as they may be simply piped to receive a small stream of water which can usually be utilized for steam or drained to the hotwell.

For taking care of the ashes, a sheet-iron apron is provided which extends across the width of the chain and as far back as any siftings would be likely to fall through. The action of the returning roller grates on this apron carries these siftings forward and deposits them on a front plate convenient for reclaiming; the ashes falling into the pit beyond this apron are seen to be kept separate.

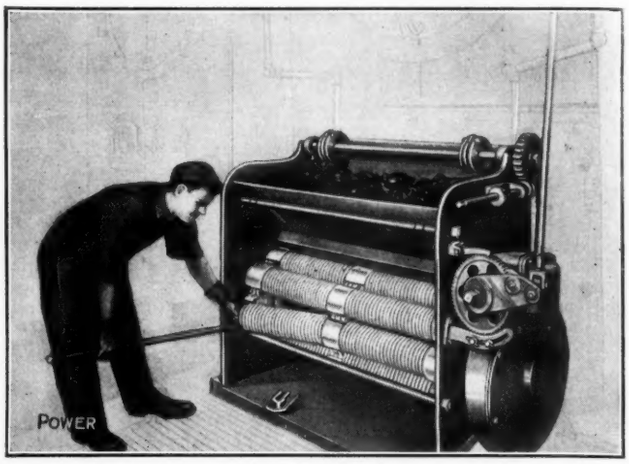


FIG. 2. REMOVING A SECTION OF DISKS WHILE STOKER IS MOMENTARILY STOPPED

As to the power required to operate this stoker, it is said that with a 20-in. crank attached to the gear shaft, one may easily revolve the stoker when carrying a fire. The chain glides on rollers and the driving sprocket is encased in oil. The stoker may easily be lowered or raised at the bridge wall to suit combustion while in

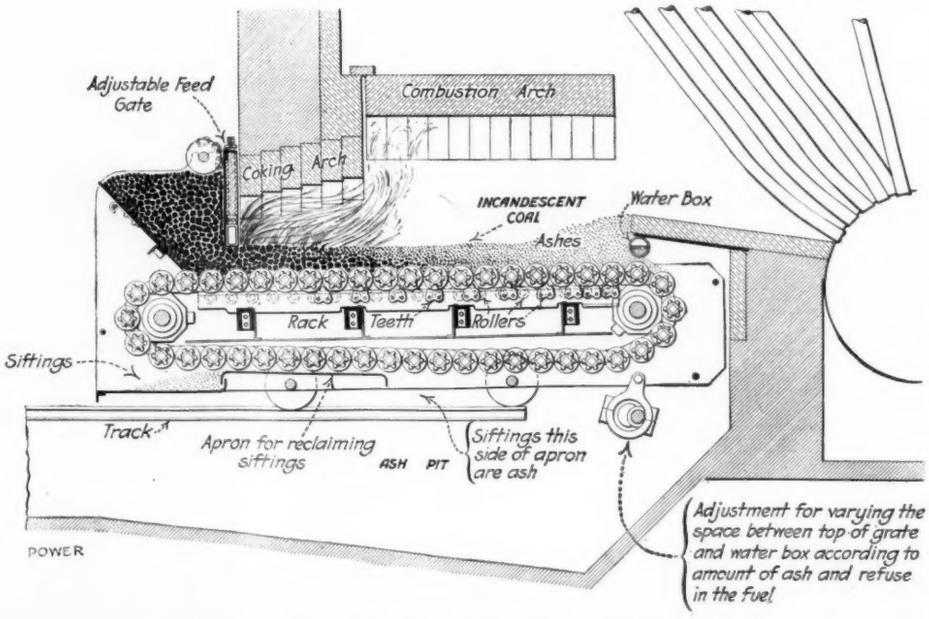


FIG. 3. SECTION OF FURNACE HAVING KEYSTONE STOKER

operation by an eccentric and a worm shaft reached from the side of the furnace. The amount of fuel sent to the furnace may be regulated by a slide gate, and the speed of the grate may also be regulated from the outside.

As will be seen in Fig. 3, the setting shown has a rather long ignition arch and a combustion arch to assist in burning the volatile. The stoker is of very heavy and rugged construction.

Motors, Their Principles and Uses--III

By Gordon Fox

SYNOPSIS—Classification of polyphase alternating motors, together with the operating characteristics and methods of starting each type.

Alternating-current motors can be operated upon single-, two- or three-phase circuits. The earlier central stations generated for single-phase transmission and the few small motors then in service were of the single-phase type. When the use of electricity for power purposes was actively promoted it was found that the polyphase motor was better suited to most classes of work, particularly for the larger installations, consequently the polyphase system and polyphase motors have been highly developed and are now much more widely used.

Polyphase motors, in which class may be included all two- or three-phase machines, are of two distinct types, the induction and the synchronous motors. Of these the former is the more common.

The Induction Motor

The induction motor consists primarily of two parts, one stationary, the other rotating, each of which carries windings. The inside of the stator is slotted and its windings are made up of coils similar to those used in the armature of a direct-current motor. The rotor is also slotted and carries windings. Both the rotor and stator cores are built up of thin iron or steel punchings called laminations which are tightly stacked together; the general arrangement of winding is shown in Fig. 1. The coils of the stator are connected to form distinct groups of poles. In a two-phase motor there are two separate circuits and in a three-phase motor, three circuits. When alternating currents are applied to the stator windings a rotating field is set up.* Following the law of closed circuits in varying fields there are generated in these circuits counter voltages which oppose the impressed line voltages, due to which action only comparatively small currents flow through the low resistance of the stator circuits although large voltages are impressed.

While the current in one phase or circuit passes through a complete cycle the magnetism rotates through 360 magnetic degrees or the space of a pair of poles. This relation holds true no matter how many polar groups there may be on the stator. Consider a 60-cycle current impressed upon the windings of a six-pole motor which has windings arranged with six poles for each phase. For each cycle the field will shift over two polar spaces or one-third of the circumference. Hence the total speed of rotation will be 60 divided by three or 20 revolutions per second or 1200 per minute. In general, the speed per minute equals

$$\frac{cycles \times 60 \times 2}{number\ of\ poles}$$

Now consider the rotor to be placed in thi rotating field. Its conductors are cut by the shifting lines of force and an electromotive force is induced in them. As they are arranged in closed circuits a current flows through them. A current flowing through a conductor in a magnetic field sets up a torque as was stated in Part 1† and this sets the rotor in motion. If there is no load upon the shaft the rotor will pick up speed until it rotates nearly as fast as the rotating field. It can never quite attain a speed in synchronism with the rotating field, for if it did no lines of force would be cut and there would be no torque to overcome friction, etc. As load is placed upon the shaft the rotor lags or "slips" behind synchronous speed so that more magnetic lines are cut, more current is generated and enough torque results to meet the demands of the load.

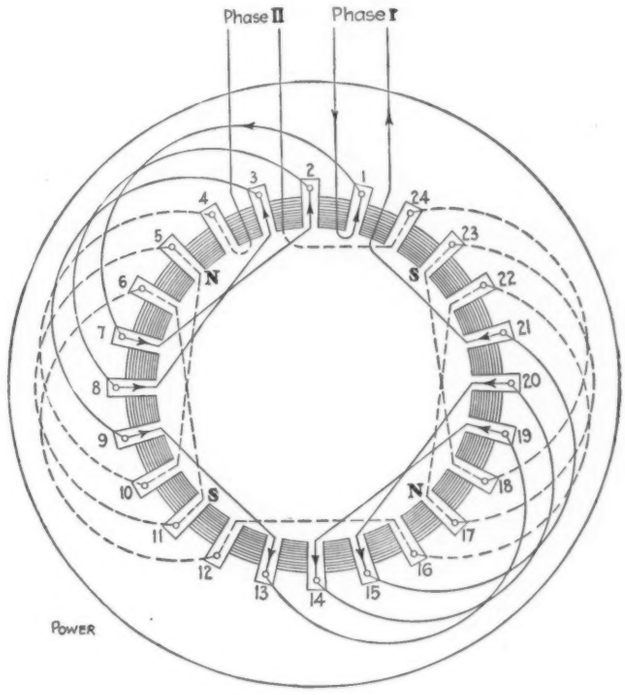


Fig. 1. Arrangement of Stator Wining in Two-Phase Motor

*For a description of this rotating field action see "Power," Oct. 14, 1913, page 536.

†See Sept. 22, 1914, issue.

It is evident that the current in the rotor varies with the load, although it is entirely separate from the primary circuits. It will now be shown how this demand for energy is transmitted to the supply circuit. The currents in the rotor have a magnetizing effect which opposes the primary magnetism and it will be recalled that the current in the primary is controlled by the counter electromotive force induced by the primary magnetism. As the rotor magnetizing effect opposes the primary magnetism

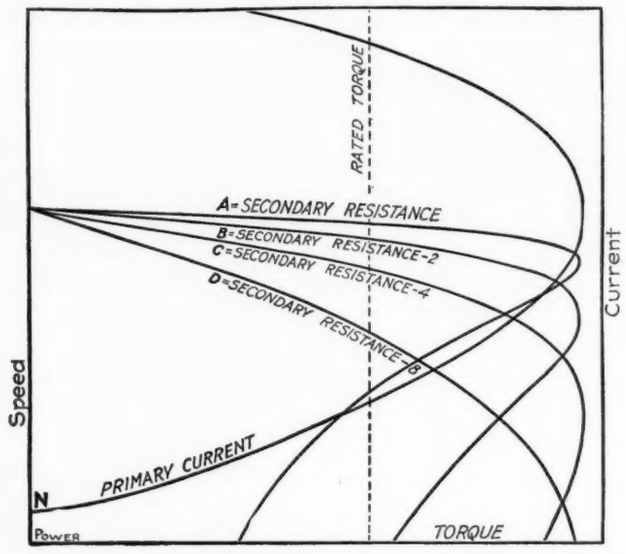


FIG. 2. SPEED-TORQUE CURVES FOR WOUND-ROTOR TYPE, WITH DIFFERENT SECONDARY RESISTANCES

the counter electromotive force is reduced and a greater primary current is received from the supply circuit.

SPEED CHARACTERISTICS

As the secondary voltage is that necessary to drive the secondary currents through the windings, it follows that the voltage required must depend upon the resistance of these windings. A larger resistance means a larger voltage for the required current and therefore a larger number of magnetic lines cut or a greater drop in speed. The torque being held constant, any variation in the secondary resistance requires a proportionate variation in the slip. If the slip with a given torque is 10 per cent., for instance, it will be 20 per cent. for double the resistance. The secondary resistance may be in the windings themselves, or may be external to the windings but part of the rotor body, or it may be entirely separate from the machine and connected to the windings by the proper leads.

Fig. 2 shows the speed-torque curves for a motor with different resistances in the secondary circuit. In curve *A* the secondary resistance is small and in curve *B* it is doubled. The maximum torque remains the same but the slip for any given torque is doubled. This motor starts much better than that in curve *A*. In curve *C* the resistance is again doubled and the slip is also doubled. The starting torque at rest is increased but the slip at rated torque is rather large. In curve *D* the slip is again doubled. The torque in this case is high at starting but falls rapidly as the speed increases. All the curves have the same maximum torque. So far as torque is concerned curve *D* is the best for starting. But for running curve *A* gives the least drop in speed. Consequently if a resistance is introduced at starting that will give the speed-torque *D* it should be cut out or short-circuited for the running position.

A current-torque curve plotted on the same figure will help to show the relations of starting to running currents with the secondaries of differing resistances. Beginning at the point *N* of no load or zero torque, the curve rises quite uniformly until the maximum torque is approached. Beyond this the current increases as the motor tends to slow down and stall. The upper portion of the curve corresponds to the starting period. Comparing the different curves it will be seen that *A* takes the most current at starting and gives a low torque; *B* takes less current and gives more torque; *C* takes less current than *B* and *D* less than *C* and delivers maximum torque at starting. From these curves it is evident that a high resistance rotor or secondary circuit gives the highest starting torque with the least current demand. Therefore, for a given torque there is no difference as far as current is concerned, the curves all having the same current for the rated torque, but operating at different speeds. As horsepower is proportional to torque and speed it will be seen that, although the current demands are the same the output is proportional to the speed. Thus motor efficiency and speed regulation are intimately related.

The secondary circuits of the majority of induction motors are of so-called "squirrel-cage" type, consisting of a series of heavy bar conductors passing through the rotor slots with their ends connected to a short-circuiting ring. This type has the advantage of extreme simplicity and absence of any form of brushes or contactors. It can only be used, however, for motors having speed-torque characteristics similar to curves *A* and *B*, Fig. 2.

When a motor is desired to give heavy starting torque with low current as in curves *C* or *D*, it is necessary to arrange the conductors on the rotor in separate circuits, usually three-phase, and to short-circuit them through a resistance connected within the rotor and manipulated by an external lever or to bring the terminals of the cir-

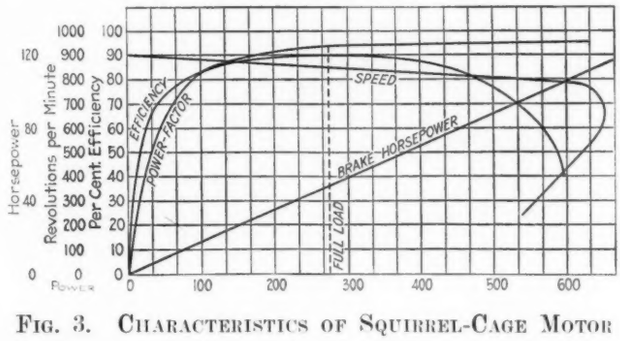


FIG. 3. CHARACTERISTICS OF SQUIRREL-CAGE MOTOR

cuits to collector rings mounted on the shaft. Upon these rings brushes bear, which lead to secondary resistance grids placed external to the machine. It must be noted that the rotor currents are heavy and if the rotor resistance is to be made high, there will be a considerable loss of energy appearing as heat. As only a moderate amount of heat can be well radiated from the motor itself it is necessary to provide high-resistance secondary motors with external resistance.

Fig. 3 gives a set of typical characteristic curves of a squirrel-cage induction motor. In a general way the characteristics are similar to those of a direct-current

shunt-wound motor. The speed regulation is good up to a point materially beyond full load. At 2¼ times full load, the motor reaches its "pull out" torque, at which point it will stall.

This motor has an improved power factor when operating on the heavier loads, the best point being above full load. The effect of a low power factor upon a motor

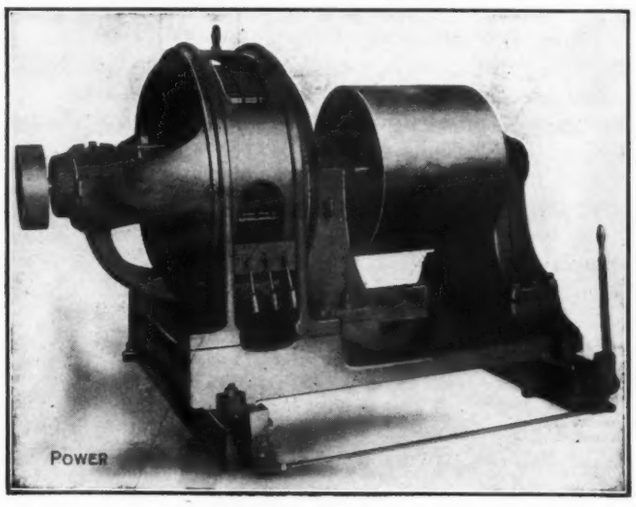


FIG. 4. TYPICAL SYNCHRONOUS MOTOR

circuit is to injure the voltage regulation as well as require more copper in the wiring.

External resistance or slip-ring motors have characteristics corresponding closely with those of compound-wound direct-current motors. The efficiency falls off more rapidly, however, with an increase of load.

Returning to the speed-torque curves in Fig. 2, it is seen that the speed under a given load depends upon the rotor or secondary resistance. By changing this resistance in external-resistance slip-ring motors, it is possible to change the load speeds materially. The maximum possible speed is slightly below synchronous speed with all resistance cut out and this may be reduced about 50 per cent. by the insertion of resistance. The drawbacks to this system of obtaining variable speed are the same as those of direct-current motors with armature control. The speed fluctuates widely with a change of load and the system is inefficient. It is not suited to machine-tool or similar work.

It is possible to change the speed of an induction motor by changing the primary voltage. A reduction of voltage greatly reduces the torque, however, and a high resistance rotor is required together with a motor having a small air gap and very little magnetic leakage. Moreover, the speed fluctuates with the load just as in the variable rotor-resistance method and the efficiency is reduced with the speed.

It was seen that the speed of the primary magnetic field was dependent upon the number of poles in the rotor. Motors are built with provisions for changing the pole grouping and thus changing the speed. This method is practical only for small sizes. There is no alternating-current motor on the market having adjustable-speed characteristics similar to a direct-current shunt motor with field control.

SYNCHRONOUS MOTORS

The simple synchronous motor is almost identical in construction with the ordinary revolving-field alternator. It is usually built for polyphase currents and in the larger sizes. Fig. 4 shows a typical machine of this type. The stator is practically identical with that of the ordinary induction motor, grouped windings in the laminated stator setting up a rotating magnetic field. However, instead of placing in this field a drum carrying closed conductors, there is placed a set of radial electromagnetic poles, the arrangement of which is shown in Fig. 5. Due to the rotor magnetism acting upon the stator conductors carrying current, a torque is exerted and causes the rotor to revolve. It might appear that the greatest torque would be exerted when the rotor poles are directly under the stator poles at the instant they receive the maximum current in the cycle; this is not the case, however. Due to the rotor magnetism cutting the stator conductors, a counter electromotive force is generated in the latter, which is opposed and nearly equal to the impressed voltage, and the rotor lags a trifle. The counter electromotive force does not reach its maximum value in opposition until the rotor poles arrive under the stator poles, at which time the impressed voltage is already decreasing. There is thus a phase difference between the two voltages, giving rise to a resultant voltage which forces through the stator a current and thus produces a torque by reaction upon the rotor magnetism. If the load increases further the rotor will lag more, allowing a greater phase difference hence a greater current and greater torque.

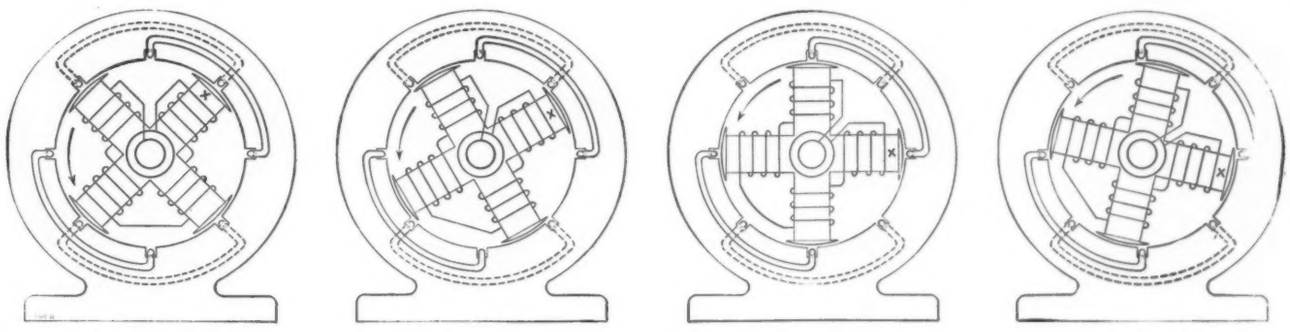


FIG. 5 FIG. 6 FIG. 7 FIG. 8

CURRENT ACTIONS IN SYNCHRONOUS MOTOR

In the foregoing, the rotor field current has been considered constant. Variation of the field current will now be taken up. It was evident that the rotor will always

assume such a position that the phase difference between the impressed and the counter voltage is sufficient to allow a load current to flow through the stator coils just sufficient to produce the torque demanded. If the field current be increased the rotor magnetism will increase, thus increasing the counter voltage. The rotor will then drop back until the increased counter voltage is further out of phase with the impressed voltage, thus maintaining the load current and torque. This may be viewed in another way if it is noted that when the rotor and stator have the position of Fig. 6, the magnetizing effect of the stator current favors the rotor field, while in position of Fig. 7, the stator effect is in opposition to the rotor field. Thus if the rotor has a weak field it will assume some such position as in Fig. 6, in order that the magnetism may be maintained, retaining the counter voltage at the proper value to apportion the load current to the demand. If it has a strong field it will act in the opposite manner.

This brings out the fact that if the rotor-field strength is varied, the stator exerts a magnetizing effect to adjust the magnetism, counter voltage and consequent load current and torque to the proper values to maintain equilibrium. Now this magnetizing effect is caused by a magnetizing component of the current intake. It has been previously stated that the magnetizing current always lags 90 degrees behind the voltage causing it. Hence the amount of lagging current received by the motor depends largely upon the field strength of the rotor. In the case of Fig. 7, the rotor field is neither magnetized nor demagnetized, being merely distorted; there is thus practically no lagging current. In the case of Fig. 8, the magnetizing current has a negative value. It lags behind the counter voltage and is reversed in phase or leads with respect to the impressed voltage.

To summarize: For load there is a definite load current in phase with the impressed voltage which represents the actual power input; this represents the output plus the losses. There is in addition a magnetizing current 90 degrees out of phase with the impressed voltage which maintains the magnetism at the proper value to develop the torque required. The magnitude of this current depends upon the strength of the rotor field current. The total current taken is the resultant of these two components. It is evident that for a given load the current intake may be varied over a wide range by varying the field strength. With a weak field, a heavy current is drawn mostly lagging. As the field strength is increased, the amount of lagging current, hence the total current decreases and comes more nearly in phase with the voltage. At one value of field current there is no lagging current, hence the total current intake is a minimum and the power factor is 100 per cent. As the field is strengthened, the current again increases, a portion now being leading. With extreme values of field strength it is possible to obtain excessive current intakes due to the heavy magnetizing components.

All induction motors draw more or less lagging current from their supply circuits. In order to neutralize the effect of this lagging current an over-excited synchronous motor is often used in connection with large installations of induction motors. If a synchronous motor be used in this way with a heavy leading current its actual power output must be materially reduced. Ordinarily it is figured that the motor shall deliver about 50 per cent. of its rated capacity in power delivered at the shaft.

The heating of the motor is proportional closely to the total current intake and if a large component of leading current is introduced the power component must be reduced. The rotor field current cannot be reduced too much, due to instability. It was shown that the effect of additional load is to cause the rotor to lag. This decreases the favorable magnetizing effect of the stator and beyond a central point the effect is remagnetizing. If a motor with a weak field reaches this point, it will evidently lose magnetism, hence torque, and become stalled more quickly. If the field be heavily magnetized it can operate at a greater angularity in the demagnetizing quadrant before losing its magnetism and torque.

A source of direct current is necessary in order to magnetize the poles of the rotor. For this purpose, a small direct-current generator or exciter is commonly mounted on the motor shaft extension or belted thereto. This exciter is usually rated at about 5 per cent. of the motor capacity.

A synchronous motor drawing a leading current at one load may draw a lagging current at another, the proper excitation changes with the load. Therefore, this type of motor requires intelligent care and attention for its successful operation.

Starting Motors

These motors are started either by means of a small induction motor, usually mounted on the same shaft, or by induction-motor action in the motor itself, brought about in most commercial machines by placing copper conductors in the field-pole faces and connecting them with short-circuiting rings just as is done in the squirrel-cage induction type. They are usually started under reduced voltage to decrease the inrush of current and the field circuit is left open until the motor attains full speed. At the instant of starting a high voltage is induced in the field coils by transformer action. In some cases the field circuit is so arranged that it can be divided into sections during the starting period to reduce the total voltage generated; otherwise the coils must be well insulated.

Small squirrel-cage induction motors, five horsepower and below, are ordinarily started by throwing them directly across the line. During the accelerating period, a heavy rush of current occurs, three or four times full-load current usually. To prevent the fuses blowing at starting, a double-throw switch is provided, fused on one side only. The motor is started by throwing the switch to the unfused side and when it has attained full speed, the switch is thrown to the fused side which is ordinarily fused for 1½ times full-load current. A spring device is provided on switches of this type to prevent leaving the switch on the starting position.

Large squirrel-cage motors are usually started under reduced voltages to decrease the rush of current and to lessen the mechanical strain on the motors and machinery. The voltage reduction may be accomplished by the insertion of resistance in the primary circuits or by means of an autotransformer. The purpose is only partially accomplished by the resistance method as the useless loss in resistance at starting increases the current demand during the accelerating period. Autotransformers are arranged with several taps allowing a selection of starting voltages according to the

torque desired. The torque of an induction motor varies as the square of the voltage. Hence for heavy torques comparatively large starting voltages are required.

Some motors are arranged for so called "star-delta" starting. Six leads are taken from the motor to the starting switch. During the starting period the windings are connected in star, which reduces the voltage impressed on each phase. When the motor attains full speed the starting switch is thrown to the delta position, in which the full line voltage is impressed upon each phase. This method is not suited to the starting of heavy loads as there is no selection of starting voltage and the motors can only be arranged to exert a comparatively low-starting torque. Also the design of the windings has to be sacrificed in some respects to adapt them to the double connection.

Slip-ring motors are usually furnished with drum-type controllers. They are arranged to start with maximum resistance inserted in the secondary circuit. The resistance is then reduced until the motor assumes the desired running speed.

Both squirrel-cage and slip-ring motors may be started by means of remote-control panels similar in appearance to those used for direct current. Controllers of this type are largely used for elevator service and for automatic control systems such as pump motors provided with a float switch in the relay circuit.

Multispeed motors are provided with drum controllers for changing the connections of the windings to obtain the various pole groupings.

Synchronous motors ordinarily require the use of a switchboard-control panel. This is provided with switches, a starting compensator of the induction-motor type, rheostats for the motor and exciter fields, voltmeter, ammeters and possibly a power-factor indicator.

Turbine-Driven Centrifugal Pumps for Water-Works

By George H. Gibson

SYNOPSIS—An analysis of the reasons why a steam-turbine-driven centrifugal pump, especially for water-works systems, is better than a reciprocating engine-driven crank- and flywheel pump. The author considers first cost, overhead charges, obsolescence of equipment, foundations and buildings, steam cost, pumping duties, maintenance and general conditions affecting the attendance of both kinds of pumps.

The choice of pumping equipment for large water-works is practically restricted to two types, the triple-expansion crank-and-flywheel pumping engine and the steam-turbine-driven centrifugal pump. Such simpler types of reciprocating pumps as compound crank-and-flywheel and triple-expansion direct-acting pumps with compensating devices, engine-driven centrifugal pumps, cost more than the turbine-driven centrifugal.

The total cost of pumping water may be divided into (1) steam costs, (2) interest and depreciation charges on machinery, foundations and buildings, and (3) expense for attendance and supplies. As regards steam costs, the triple-expansion crank-and-flywheel engine holds to date the record for duty. As an offset to high duty, the centrifugal pump offers lower first cost (hence lower annual charges), lower cost for foundations and building (as the unit occupies only about one-third to one-half the floor space and weighs much less) and less expense for supplies, such as packing, oil, waste, etc., together with greater simplicity and fewer parts, which tend to decrease the cost of repairs, replacements and attendance, notably the latter.

To illustrate how the higher steam rate of the turbine is compensated for by its lower fixed charges, assume that the head to be pumped against is 200 ft. The cost of a triple-expansion reciprocating pumping engine of large capacity for this head is approximately $3500 per million gallons daily capacity, while the cost of a steam-turbine-driven centrifugal for the same head will not be over $1000 for the same capacity. Taking the interest and depreciation charges to be 10 per cent. in each case, it will be seen that each million gallons daily capacity of the high-duty reciprocating engine must carry an annual charge of $350, whereas the centrifugal pump will be required to carry only $100, leaving $250 available to pay for any difference in steam consumption. If the average duty of the reciprocating pumping engine be assumed at 170 million foot-pounds, as against 130 million for the turbine unit, the yearly cost for steam, 16 hours per day with coal at $3 per ton, will be $13.08 per water horsepower for the reciprocating engine, as against $17.10 for the turbine-driven centrifugal pump, or a saving of $4.02 per year for each water horsepower capacity installed. Pumping at the rate of one million gallons per day against 200-ft. head corresponds to about 35 water horsepower, upon which the yearly saving of $4.02 would amount to $140.70. Subtracting this from $250 saved by the turbine-driven centrifugal pump on fixed charges, leaves $109.30 for each million gallons daily capacity in favor of the steam-turbine-driven centrifugal-pump unit.

The turbine-driven centrifugal pump maintains its duty better than does the reciprocating pump, as there are no adjustments and but few parts subject to wear, and will usually save about one-half the cost for attendance, except in small plants, where only one man is required.

With the reciprocating pump there is a continual expense for valves and packings, neither of which enter into the cost of upkeep of the turbine and centrifugal pump. The expense for oil and waste of the former is also considerable, while with the turbine it is negligible, since the latter employs a closed oiling system using the oil over and over. Cylinder oil, which is a heavy expense with large multiple-cylinder reciprocating engines, is not used in the turbine. In addition, there are many minor supplies, such

as gaskets, small packings, etc., which must be kept in stock for the reciprocating pump, but are required very little or not at all by the turbine unit.

The life of machinery is frequently figured at 20 years, requiring 3.23 per cent. to be charged off per year to a sinking fund drawing interest at 4 per cent. Some engineers have assumed a higher percentage or rate of depreciation on steam-turbine-driven pumps than on reciprocating pumps for the same conditions, but the yearly

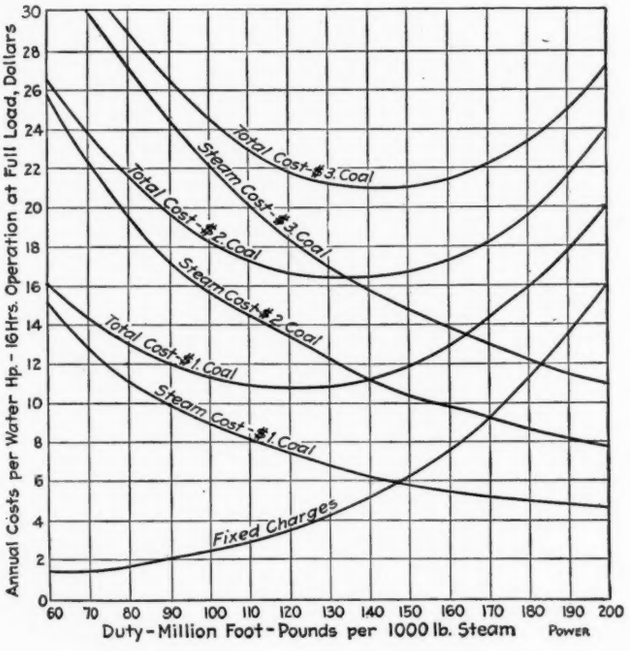


FIG. 1. COSTS PER WATER HORSEPOWER

cost of maintaining turbine-driven centrifugal-pumping equipment is no greater in percentage of first cost than is the yearly cost of maintaining reciprocating equipment.

The depreciation on machinery is often figured at a higher rate than that on buildings and foundations, and while it may be true that the latter will last longer than machinery, so far as natural wear and tear are concerned, it is not correct economically for the reason that when the machinery has outlived its usefulness or has become obsolete, the buildings and foundations, and in fact, the entire equipment, is often obsolete and must be torn down and replaced. Changing conditions may require removal or abandonment of the plant, as where the water supply has become contaminated or insufficient filtering equipment is available, etc. Old buildings are seldom available for new equipment, although in perfect condition and repair. In any case, depreciation on foundations should be equal to the charge on machinery, for the reason that it is seldom that old foundations can be used for new apparatus, or at least not without considerable remodeling, at an expense equal to that of new foundations.

The difference between the costs of the foundations and buildings for steam-turbine-driven centrifugal pumps and those for reciprocating pumps is in favor of the steam-turbine unit. Large and expensive foundations are required for reciprocating pumps, not only because of the great weight of the machine, but also to resist the vibration and strains due to unbalanced reciprocating motion. The steam-turbine-driven pump requires a comparatively small building with but little headroom, and of comparatively light construction, as the parts to be handled by cranes are small, while the reciprocating pump requires large, high buildings, substantially built to support cranes of large capacity. Where the conditions for foundations are bad, the advantages of the centrifugal pump become still greater.

The fixed annual charges on pumps increase with the duty and at a rapidly increasing rate, as shown by the lower curve in Fig. 1. The minimum total pumping cost is found where the sum of the annual charges and steam cost is a minimum, which is also the point where the slope of the fixed-charges curve is equal and opposite to the slope of the steam-cost curve. The minimum cost of pumping is not necessarily at the point where the two elements of cost are equal, but may be found at a point where the annual charges are still considerably less than the steam cost. The curve shown for annual charges is based on recent quotations on pumping engines. In a specific case, the chart has little value further than for a preliminary sizing up, as the decision must be based on definite prices and guarantees submitted on the individual installation. The turbine-driven centrifugal pump, however, has the advantage for all prices of coal up to about $6 per ton.

Under practical working conditions, the turbine-driven centrifugal pump often nearly equals in duty the triple-expansion, crank-and-flywheel pumping engine, particularly if the average duty, as affected by wear and slippage, and also the greater ability of the turbine pump to make profitable use of high steam pressures, high superheats and better vacuums be considered. The steam turbine can utilize high-pressure and superheated steam without the lubrication troubles encountered by reciprocating engines.

The reciprocating engine shows little improvement with increase in vacuum above 25 or 26 in., but the steam turbine is able to take care of the very much greater temperature range which high vacuums supply. For example, in a pound of steam expanded from an initial pressure of 150 lb. to 25-in. vacuum, there are available for conversion into work 234 heat units, an increase of 45 per cent. While the steam turbine is able to turn a larger proportion of this heat made available by higher vacuum into increased duty, the reciprocating engine shows little, if any, improvement. As a general statement, it may be said that for a pumping unit having a capacity equivalent to 700 water-horsepower or over, and with standard turbine steam conditions, the turbine-driven centrifugal pump can be made to show a duty of over 150 million foot-pounds per 1000 lb. of steam.

It should be borne in mind that duty guarantees based on plunger displacement are of little value, because of slippage. For example, in one of the largest municipal water-works, where a force of men is employed solely to measure the duties of pumping engines, slippages as great as 15 to 30 per cent. are occasionally found. A slippage of 2 or 3 per cent. is disregarded, and an engine is not overhauled until the slippage exceeds 4 per cent. Asuming the duty of an engine based on plunger displacement to be 170 million foot-pounds per 1000 lb. of steam, this at once reduces the duty to 163.2 millions. In other words, a reciprocating pumping engine showing 170 millions duty measured by plunger displacement and having a slippage of 4 per cent. would probably be doing no bet-

ter, as measured by work delivered in the water, than would a centrifugal pump having a duty of 162 millions.

The Turbine Centrifugal-Pump Problem

The problem of directly connecting the steam turbine to drive the centrifugal pump arises from the great disparity between the spouting velocity of steam and the peripheral velocity required of the pump impeller. For a turbine developing about 1000 shaft-horsepower, the ideal speed is between 4000 and 5000 r.p.m. To reduce the speed below this with a given number and size of wheels will cause the duty of the turbine to fall off because of high velocity in the steam as it leaves the buckets, while to reduce the speed by adding more stages will increase losses by steam friction unless the diameters of the wheels be reduced, which reintroduces leakage and leaving losses. The use of a large number of stages also increases the first cost of the turbine.

Fig. 2 shows the relation between delivery and efficiency when pumping against a constant head, the delivery being controlled by varying the speed.

Suppose a 1000-hp. turbine operating at 4500 r.p.m. is to be directly connected to a centrifugal pump delivering water against a head of 200 ft. The peripheral velocity required of the impeller will be about 115 ft. per sec., and as the capacity of the pump will be about 15,000 gal. per min., the speed will be approximately 1000 r.p.m., that is, about one-fourth of the turbine speed. By using two pumps, each of half the capacity, this speed can be increased in the ratio of the square root of 2 to 1, or 1.4; 1.4 times 1000 is 1400 r.p.m.. Or by using three impellers in parallel, it may be increased in the ratio of the square root of 3 to 1, or to 1730.

As this is still considerably short of the best turbine speed, the only remaining alternative, if the turbine is to drive the pump directly, is to compromise between the two speeds—that is, reduce the turbine speed and increase that of the pump. The speed of the turbine may be reduced by adding more stages, and by running below the most favorable speed for the given number of stages.

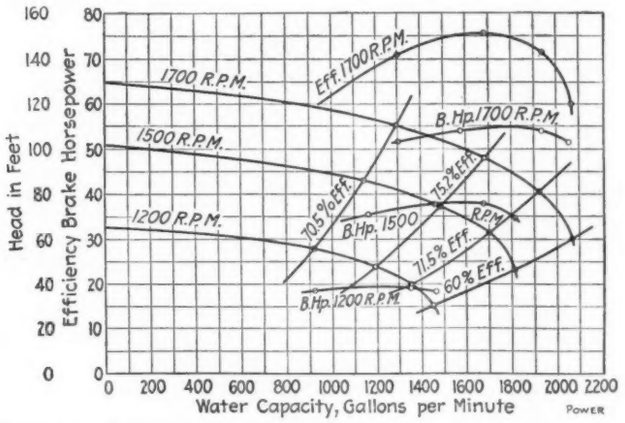


Fig. 2. Relation between Delivery and Efficiency When Pumping against Constant Head

The pump speed may likewise be increased by increasing the entrance velocity and using a smaller impeller. Each has a detrimental effect upon the respective efficiency.

As for the pump, the increased velocity of entrance is secured at the expense of the suction head and this velocity head must be reconverted into pressure head at the delivery. Inasmuch as this reconversion is not perfect, an additional loss of work is imposed upon the pump over what would be necessary were a normal entrance velocity used. Obviously, this method of increasing the speed is the more unfavorable the less the total head to be overcome. For moderate and large capacities this compromise involves the use of several impellers operating in parallel and running at high speed with high water velocities, which is apt to introduce mechanical and hydraulic unbalancing and vibration, with consequent pitting and erosion, necessitating frequent renewals.

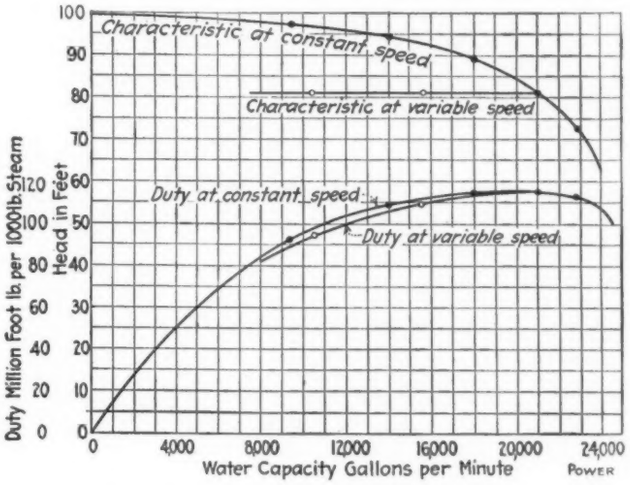

Characteristic at constant speed
Characteristic at variable speed
Duty at constant speed
Duty at variable speed
Duty Million foot lb per 1000 lb. Steam
Head in Feet
Water Capacity Gallons per Minute
POWER

Fig. 3. Duty as Affected by Speed

The solution of the speed problem which has been most successful is the use of a mechanical speed-reducing gear between the turbine and the pump. This permits of running each member of the unit at its most favorable speed, having regard solely for its own characteristics. If the turbine be operated at the speed corresponding to its maximum efficiency, it is possible to vary the speed considerably while affecting the steam economy very little. This feature is useful where a pump is to be operated at different rates of delivery, as will be apparent from Fig. 3.

Test of J-M Boiler Preservative

Dr. C. E. Ford, commissioner of the department of public welfare, Cleveland, Ohio, recently made a laboratory test with J-M boiler preservative. He determined that no danger whatever existed from its being carried over with the steam, and furthermore, even if the preservative were to carry over, there would be no contamination of food products, if the steam were used for cooking, as it is composed of natural, harmless salts extracted from the sugar beet.

This preservative is the enemy of boiler scale, its action being partly chemical and partly mechanical. On account of its strong affinity for iron, it works its way through the cracks of the scale, causing it to loosen and drop off when the boiler is blown off or washed out.

It is also used to neutralize the acid properties of feed waters and to bring the alkalinity test up to the point at which corrosion and pitting will stop. It forms a thin coating on the iron and, when used regularly, prevents scale-forming elements from adhering to the metal.

The preservative is manufactured by the H. W. Johns-Manville Co., New York City.

Down-Draft Heating Boilers*

By Osborn Monnett†

SYNOPSIS—Typical heating boilers and designs of furnace for smokeless operation. Ringelmann chart readings from these boilers show good results.

Being peculiarly adapted to low rates of combustion, the down-draft grate works out well for heating loads. Although with some types of equipment it is not possible to get the long flame travel obtained in power boilers, still the infrequent intervals between firing insure a good supply of coked coal on the upper grate, which, if carefully poked down, need not make any smoke. The secret of success with this type of furnace is to carry a thick, heavy fire on the upper grate in order to accumulate as much coked coal as possible before poking.

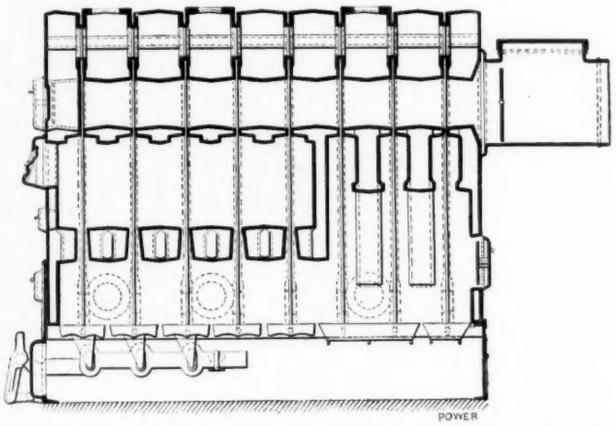


Fig. 1. American Radiator Co.'s "Ideal" Boiler

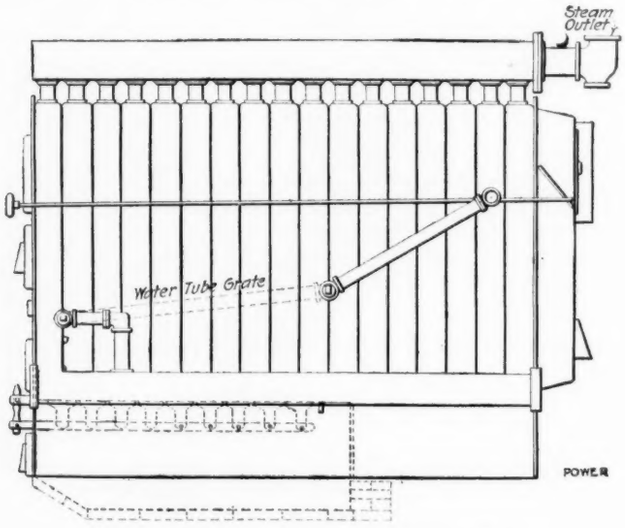


Fig. 2. Hart and Crouse Royal Boiler

A number of types of down-draft boilers for low-pressure work are shown in Figs. 1 to 6. Figs. 1 and 2 show two types of cast-iron boiler, one having the down-draft water grate cast in the section of the boiler and the other a water-tube grate made up between headers in the ordinary way.

Figs. 3 and 4 illustrate the firebox type of down-draft boiler, the difference in the construction of the water grate being plainly shown. Two styles of uptake are shown, either of which can be used with either boiler.

Fig. 5 shows a Herbert detachable down-draft furnace installed in connection with a return-tubular boiler, with a two-span deflection arch for gas mixture. Another interesting setting of the same type is shown in Fig. 6. It consists of an Evans-Almirall hot-water installation made up of a typical down-draft grate under a 54-in. by 14-ft.

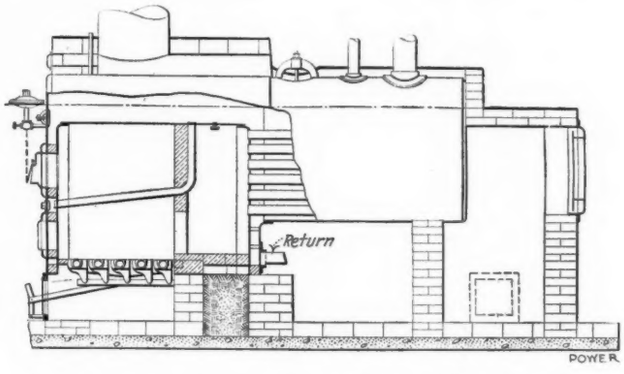


Fig. 3. Brennan Firebox Down-Draft Boiler

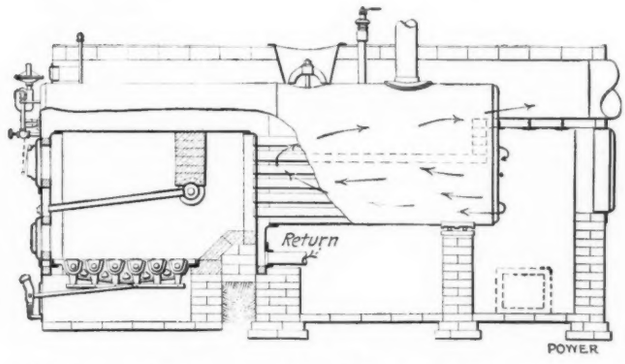


Fig. 4. Kewanee Firebox Down-Draft Boiler

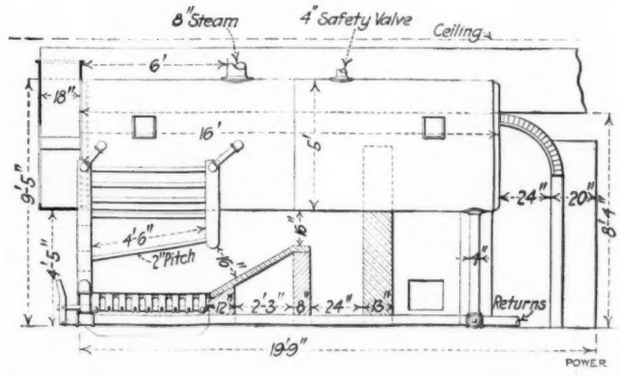


Fig. 5. Herbert Detachable Down-Draft Furnace under 60-In. by 16-Ft. Return-Tubular Boiler

*Copyright, 1914, by Osborn Monnett.

†Smoke Inspector, City of Chicago.

return-tubular boiler. In the combustion chamber is fitted a V-pier and wing walls similar to the No. 8 furnace previously described. This makes a good combination to use whenever the return-tubular type of boiler is employed. The areas are worked out the same as for the power boilers previously described.

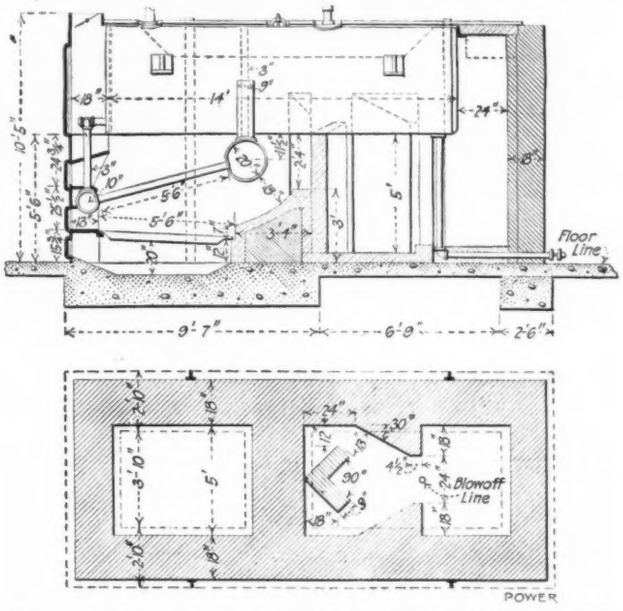


FIG. 6. EVANS-ALMIRALL DOWN-DRAFT BOILER WITH V-PIER AND WING WALLS

TABLE I. RESULTS FROM DOWN-DRAFT HEATING BOILERS BURNING ILLINOIS COAL

Name	Minutes of Observation	Smoke Units	Per Cent. Density
1	240	42.5	3.5
2	240	46.5	3.8
3	240	37.0	3.0
4	240	73.5	6.1
5	240	61.5	5.1
6	240	63.25	5.2
7	240	51.5	4.3
8	240	45.5	3.8
9	240	20.75	1.7
10	240	112.0	9.4
11	389	67.5	3.4
12	180	29.0	3.2
13	240	96.0	2.0
14	240	5.25	0.4
15	240	26.0	2.2
16	240	67.25	5.6
17	240	20.25	1.7
18	240	20.0	1.6
19	240	00.0	0.0
20	240	42.0	2.0
21	240	87.75	7.8
22	240	21.5	1.8
23	220	99.0	9.0
24	240	18.0	1.5
25	240	00.0	0.0
26	240	58.5	4.9
27	240	00.0	0.0
28	240	135.5	11.2
29	240	23.0	1.9
30	240	49.75	4.2
31	240	36.5	3.1
32	240	58.5	4.8
33	240	6.0	0.5
34	240	50.5	4.2
35	240	00.0	0.0
36	240	00.0	0.0
37	240	71.5	5.9
38	240	00.0	0.0
39	240	66.5	5.4
40	180	5.5	0.6
41	180	00.0	0.0
42	180	6.0	0.6
43	240	8.0	0.6
44	240	41.0	3.4
45	240	86.75	7.2
46	240	00.0	0.0
47	240	60.0	5.0
48	240	11.0	9.0
49	240	0.5	0.1
50	240	84.25	7.0
51	240	67.0	5.6
52	240	7.25	0.6
53	240	15.25	1.3
54	240	00.0	0.0
55	240	102.25	8.5
56	380	39.5	2.6
Total	13,649	2244.5	3.28

A series of Ringelmann chart readings were taken in Chicago during the past heating season on down-draft boilers using various fuels and on plain firebox boilers using Pocahontas coal. The results are tabulated herewith. Bearing in mind that from 2 to 5 per cent. is considered a satisfactory performance for hand-fired boilers, it can be seen how near the ideal was approached by the average of all the readings taken.

TABLE 2. RESULTS FROM DOWN-DRAFT HEATING BOILERS BURNING POCAHONTAS COAL

Name	Minutes of Observation	Smoke Units	Per Cent. Density
1	240	15.0	1.2
2	240	1.5	0.1
3	240	7.5	1.5
4	240	9.25	0.8
5	240	48.5	4.0
6	240	39.0	3.25
7	240	00.0	0.0
8	360	5.0	0.3
9	240	54.75	4.5
10	240	52.0	4.3
11	240	2.75	0.23
12	240	3.5	0.3
13	240	5.5	0.4
14	240	5.0	0.3
15	240	2.0	0.2
16	240	29.0	1.9
17	240	3.0	0.3
18	240	67.24	5.6
19	240	00.0	0.0
20	240	14.25	2.1
21	240	3.0	0.3
22	180	3.0	0.3
23	240	17.25	1.4
24	240	16.5	1.3
25	240	19.5	1.6
26	390	18.0	0.9
27	240	5.0	0.4
28	240	0.0	0.0
29	240	0.0	0.0
Total	7170	441	1.2

TABLE 3. RESULTS FROM CAST-IRON AND FIREBOX TYPES OF BOILER, UP-DRAFT, BURNING POCAHONTAS COAL

Name	Minutes of Observation	Smoke Units	Per Cent. Density
1	225	15.75	1.4
2	240	39.5	3.3
3	240	42.25	3.5
4	240	25.0	2.1
5	240	8.25	0.7
6	240	17.0	1.4
7	240	7.5	0.6
8	240	0.0	0.0
9	240	31.0	2.5
10	240	0.0	0.0
11	240	16.25	1.3
12	240	55.25	4.6
13	240	149.25	12.4
14	240	160.25	13.3
15	240	53.0	4.4
16	240	0.0	0.0
17	240	18.75	1.1
Total	4065	539	2.7

The data were collected without the knowledge of the operators of the various plants, who were in every case the ordinary janitor found on heating jobs. When the density ran higher than 5 per cent., it was always due to carelessness. Education will be a big factor in getting better results from this type of equipment when it becomes more generally introduced.

Natural Gas Output in 1913 in the United States was the greatest in the history of the industry, surpassing that of any previous year in both quantity and value. The total gas production in 1913 is estimated by B. Hill, of the United States Geological Survey, at 581,898,239,000 cu.ft., valued at $87,846,677, an average price of 15.10 cents per thousand cubic feet, as compared with a production of 562,203,452,000 cubic feet, valued at $84,563,957, an average price of 15.04 cents, in 1912, the increase being 19,794,787,000 cubic feet in quantity and $3,282,720 in value. Of this total product, about 32 per cent. was utilized for domestic purposes, or 184,885,662,000 cubic feet, valued at $50,522,415, an average price of 27.33 cents per thousand cubic feet, and 68 per cent. was utilized for industrial purposes, or 397,012,577,000 cubic feet, valued at $37,324,262, an average price of 9.4 cents. The industrial consumption includes gas used for both manufacturing and producing power.

West Virginia led in quantity of natural gas produced and Pennsylvania was second, Pennsylvania was the leading state in quantity of natural gas consumed, and Ohio second.

Recovery of Gas-Engine Waste Heat

SYNOPSIS—By maintaining a rapid circulation through the jackets, the temperature of the water can be raised sufficiently high to produce steam at 25 to 50 lb. without danger of overheating the cylinders. In this way all the heat ordinarily wasted to the jackets is utilized in the form of low-pressure steam.

In competition with steam engines, the gas engine has long suffered a handicap where the conditions have demanded low-pressure steam for heating or industrial purposes. While some progress has been made toward utilizing the waste heat for this purpose, the practice has not been general, one obstacle being the difficulty in raising the jacket water to a sufficiently high temperature without danger of overheating the cylinder.

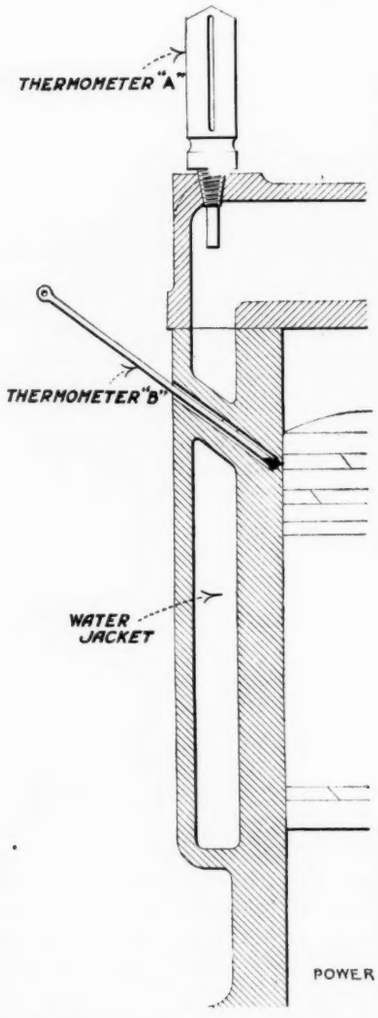


FIG. 1. METHOD OF MEASURING TEMPERATURE DROP THROUGH CYLINDER WALLS

Recent investigations by J. B. Meriam, of the Bruce-Macbeth Engine Co., indicated that when the jacket-water temperature is raised above 150 deg., bubbles begin to form and adhere to the surface of the iron. These increase in size and number with a rise in temperature until at 200 deg. the entire surface is covered with bubbles. Closer inspection showed that each bubble spreads out where it comes in contact with the iron, preventing the water from coming in contact with the surface and thus acting as a heat insulator; hence, a dangerous rise in temperature of the cylinder walls.

By forcing the water in a closed circuit through the jackets at high velocity (five to ten times normal) it was found that the temperature could be raised to at least 300 deg. (corresponding to about 50 lb. steam) without danger to the cylinder; showing that at this high velocity the insulating bubbles did not have a chance to cling to the iron.

As further proof a cylinder was provided with a boss as shown in Fig. 1, and a $\frac{5}{16}$-in. hole was drilled at an angle to within about $\frac{1}{16}$ in. of the inner surface. A drop of mercury was placed in this hole and a thermometer *B* inserted. A second thermometer *A* was then placed in the jacket as shown. It was found that the difference in temperature as recorded by the two thermometers was practically constant over a wide range of jacket-water temperatures, showing that the heat was carried away by the water as fast as it passed through the cylinder walls. In this particular engine used in the test it was found to require a little less than 30 min. to raise 10 lb. steam pressure.

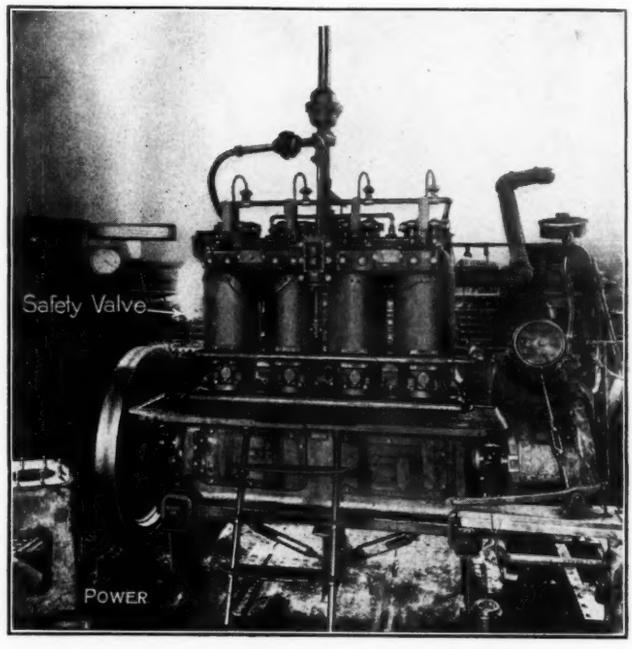


FIG. 2. ENGINE ON TESTING FLOOR

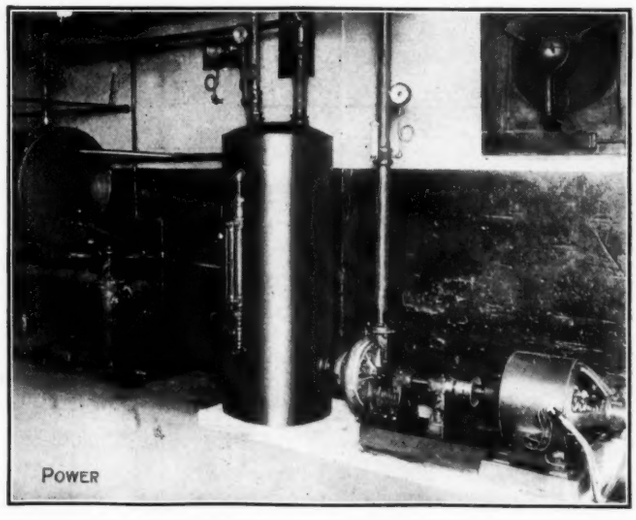


FIG 3. PART OF INSTALLATION AT YOUNGLOVE BUILDING

The distribution of heat in an efficient gas engine is about as follows:

	Per Cent.
Effective work	27
Radiation	3
Exhaust	38
Water jacket	32

It follows that if an inclosed cooling system is used, and only steam is allowed to escape, then all of the water used must eventually be turned into steam, and practically the entire 32 per cent. of the total heat of the fuel, referred to as lost to the jackets, is recovered in the form of steam.

With a well designed exhaust-gas boiler, about one-half the 38 per cent. of the total heat of the fuel which is lost to the exhaust should be recovered. This added to that recovered from the jacket water would make about 50 per cent. of the heat of the fuel available in the form of low-pressure steam. The engine on which the tests were conducted was equipped with a water-jacketed exhaust manifold (see Fig. 4), but without a specially designed exhaust-gas boiler, and it was found that the temperature of the exhaust gases leaving the engine beyond the water-jacketed manifold exceeded 950 deg. F. at full load.

The difference in temperature between the entering and outgoing water was less than 15 deg. and the cylinder was thus maintained at a practically constant temperature.

Another marked feature claimed for this process is increased thermal efficiency of the engine, so that the fuel consumed is about 2 per cent. less at maximum load and 15 per cent. less at quarter load. With an engine of high efficiency and operating at maximum load, there will be evaporated by this process approximately four pounds of water into steam at 25 lb. pressure per brake horsepower-hour delivered by the engine. As might be expected the quantity of steam generated per horsepower-hour increases as the load decreases, due to lower thermal efficiency and hence increased rates of fuel consumption at the lighter loads. On one of the tests an evaporation of 7.3 pounds of water per brake horsepower-hour was attained at quarter load.

Fig. 2 shows a Bruce-Macbeth engine equipped for this process, on the testing floor, and Fig. 3 part of the installation in the Younglove Building at Cleveland. Here there are three gas engines of 150, 60 and 30 horsepower, and one motor-driven centrifugal pump supplies the water at high velocity to the engines. Only one expansion tank is used. The horizontal tank shown is the hot-water supply for the building and is fitted with a steam coil, which receives its supply from the gas-engine jackets or from the low-pressure heating boiler in the next room. This allows the hot-water tank to be carried at full city pressure, while the jackets of the engine deal with low-pressure steam; in this case 5 to 10 pounds.

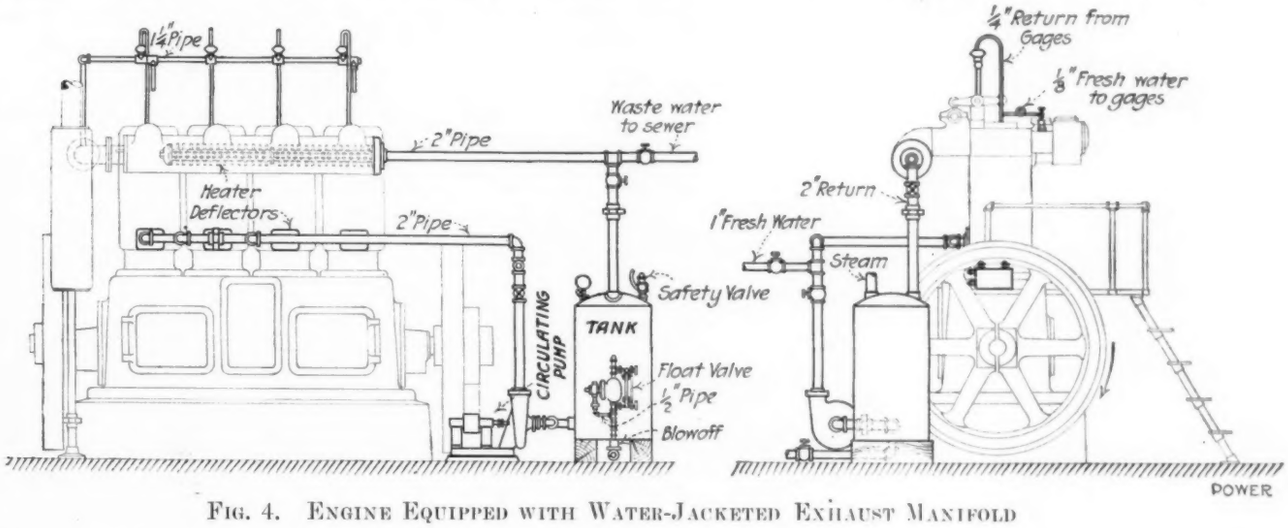


FIG. 4. ENGINE EQUIPPED WITH WATER-JACKETED EXHAUST MANIFOLD

Temperatures in the Locomobile

In the Feb. 18 issue, a sectional view of the apparatus and piping of a typical reciprocating-engine plant, operating condensing, was published. The illustration also showed the variation of temperature and pressure of the boiler gases and of the steam during the course from the boiler through the engine, condenser and back to the boiler.

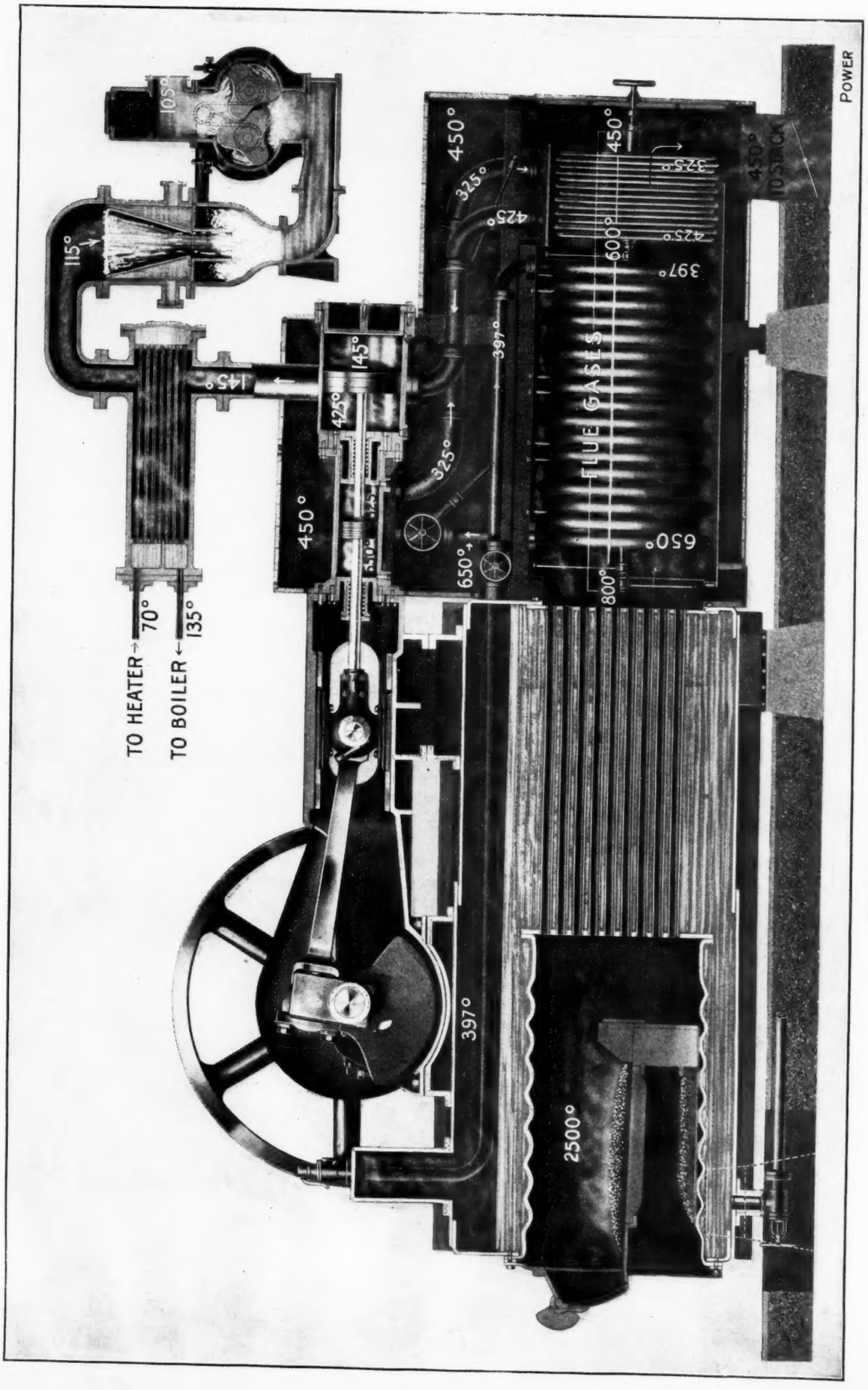
On page 496 of this issue is shown a sectional view of a locomobile with the temperature reduction from 2500 deg. at the furnace to 105 deg. at the condenser discharge.

This illustration represents just as complete a power plant, boiler, engine, heater and condenser as that in the Feb. 18 issue; a unit up to 600 hp. in capacity would require about one-half the floor area. There is no external steam piping and the main engine drives all the auxiliaries.

The heater and condenser are placed above the main unit to more clearly show the connection between them and the engine cylinders. With the ordinary unit the heater, pump and condenser are at the side of the boiler.

Isolated Power Plant for Coney Island—According to the latest report, Coney Island is to have another isolated power plant. Bids have been asked on a 2500-kw. capacity power and lighting plant, the main units to be turbo-generators. This plant will be constructed by the Luna Amusement Co., and will furnish power and lighting for Luna Park and its attractions.

Tool Rust Prevention—Tools that are used or stored in damp places can be kept from rusting by using the following protective coating: Get a half a pound of melted lard, stir in a half ounce of camphor, and skim off the scum; next add, constantly stirring, three ounces of finely powdered graphite, and apply the mixture hot to the tools after they have been cleaned and wiped dry. Any surplus of the grease can be wiped off after 24 hours with a cloth or clean waste.



DISTRIBUTION OF TEMPERATURE IN THE LOCOMOBILE

Showing how within this self-contained unit the temperature is reduced from 2500 degrees at the furnace to 105 at the condenser discharge.

Editorials

Appropriations for Smoke-Inspection Departments

Lack of money for city smoke inspection was a condition much deplored at the recent convention in Grand Rapids, Mich., of the International Association for the Prevention of Smoke.

It is difficult to make the citizens, and especially the majority of the officials seeking the support of the citizens, see that the smoke department is doing any real good. These people have no adequate conception of the nature of the work, and as soon as the department is created, all are angrily disappointed to find even one stack emitting the substance that a new ordinance, backed by a whole department, has been instituted to prevent. It is a pity that the citizens cannot be made to understand that the laws for smoke elimination are the most insignificant part of the whole thing. Mere laws will not stop smoke any more than they will complete the arrest of the offenders. It takes jails, police, patrol wagons, alarm systems, etc., to do the latter, and it requires changes in firing methods, remodeled furnaces, supervision of new construction, and much moral suasion, all of which requires time, before any really noticeable diminution of smoke occurs.

If a smoke-inspection department has competent engineers and has authoritative supervision over the design and installation of new furnaces as well as of repairs or changes to old ones the saving to individual users of fuel sometimes amounts to more than the entire appropriation to conduct the department, to say nothing of the saving to the city.

Another fact that must not be overlooked is that when the department has revised the boiler-room practice in a plant and has effected a saving to the owner, he becomes of value in helping to enforce the smoke ordinance. He informs his industrial friends of what the department has done for him, and soon, in an ever growing circle, the department is regarded as a boon instead of a pest with a legal right to existence.

To bring this condition about requires close attention by the department to individual cases. A plant that is a chronic smoker or one that becomes one after changes in coal, firing methods or settings, must be critically studied to find the cause, discover a remedy and then the owners must be persuaded to adopt it. Data concerning the case must be recorded, and an inspector must devote much time to the plant so that when similar cases arise, the department may know how to care for it.

The practice of making the smoke inspection departments of American cities one-man affairs, or nearly so, is altogether too common. In most cases, it is worse than foolish; it is pitiable ignorance or unpardonable negligence.

What is an appropriation of two, or twenty thousand dollars to reduce the cause of annual damage amounting to millions in most large cities?

Industrial Education

Much is being heard of the present being the accepted time for the United States to increase its prestige in the foreign markets. This is true, but so much of this kind of talk is likely to give the impression that this country has not figured to any extent in foreign trade heretofore, which is not so. The Bureau of Foreign and Domestic Commerce of the Department of Commerce has recently published a book, "The Commercial Relations of the United States," which shows by figures for 1912 that in that year the United States was the world's third largest importer, only the United Kingdom and Germany being ahead of it, while as an exporter this country had the lead.

So much by way of indicating that the United States has a position of importance in the world's markets already. This, however, does not deny the fact that the opportunity is here for it to gain additional foreign business, which, with the proper methods, it should be able to hold indefinitely, even after the disturbed conditions abroad may be adjusted.

One very important part in this desirable object may be played by industrial education. In this connection it is interesting to review something of the work that has been done by the National Association of Corporation Schools, as given in the report to the executive committee, abstracted on another page of this issue.

The association was formed with the idea, not of supplanting any existing forms of education or any established educational institutions, but with the hope of supplementing their work. The corporation schools do not pretend to carry along the educational courses given in the common or grammar schools, and they believe that these schools should have entire charge of the scholar until he is fourteen, or has been graduated from the grammar school. The association does not believe that the child should be taught any trade or be encouraged to select any specific industry until he is a grammar-school graduate; but it does believe that a knowledge of the industries and a broad general cultural knowledge could be taught the child between the ages of 12 and 14.

The association, now in its second year, has had enough experience to enable its executive committee to map out a constructive plan, to which the association intends to work prior to its third annual convention, which will be held in Worcester, Mass., during the second week of next June.

We believe that our readers will be interested in the report before referred to, and while the association's work is not confined to the field with which we are especially concerned, we believe that it can play a very important part in the field of power-plant engineering, as well as in other industries.

Any boost that can be given the good work by those whose attention may have been arrested by these words will be directed in a good cause.

The Market for Service

All markets are more or less regulated by supply and demand. Commodities of the highest grade usually netting the highest price and being the most readily disposed of, the market for engineering services should be a fruitful field for study.

The age is one of minute specialization. Not often is a successful engineering specialist a successful business specialist. The high-salaried man is the man who can control and direct men of genius. He is the expert broker in brain markets. That is his specialty. He makes no pretense to know engineering, but he sets the wages for engineers.

Without a market master genius is extremely liable to go derelict. The country is full of misfits. One customer is not enough to attend the market of a man's service. Competition is as needful among buyers of service as among sellers of it. Employers may have many avenues through which to get an engineer's services at their own figure. His hours are long; his days off are few. His need for employment is pressing and his fear of being out of work is great.

Let us suppose that his education has been his business; not marketing his services. All his efforts have been bent on one purpose. Fortunate indeed he is if he makes a satisfactory sale at first offering. Too often this is not the case. Intellectual giants often go about doing child's work. This is one type of misfit. The other is more hopeless. He is the man who, having spent little on his education and training, manages, by some means, to market his wares above their merit. He gets in; he bluffs; he fakes and hides his ignorance as long as he can. Then he goes down. In so doing, he does the profession more harm a hundred-fold than the first.

Let us presume that most employers are honest in their desires for the welfare of their engineers. The trouble is here again, that their "profession" has not been the "business" of *hiring* engineers. Their profession is that which causes them to *need* engineers. They are specialists, if successful in their vocation. They have been imposed upon by unscrupulous and lying vendors in the market of engineering service. They want good men as badly as good men want places. It is the bogus element that needs eliminating.

Over in the market gardening regions of New Jersey, a study has been made of soils and their adaptation to various crops is occupying the minds of specialists. For instance, in one section nobody raises anything but potatoes for miles around. Their undivided attention is given to producing, quantity, quality, economy of methods, etc. These men have to give little thought to selling, because they have a selling exchange. A marketman was selected and paid to make the selling his specialty. He must keep constantly in touch with the markets, and has become an expert business specialist.

The expert engineer needs a business expert just as much, and it might not be such a bad idea to have a business expert or a market commission or bureau keeping personal records of engineers, just as Uncle Sam has a record of every soldier in the old Ford Theatre Building in Washington. Such records would be as valuable to employers as to engineers. It would make for the elevation of the worthy, would weed out the unworthy and ultimately better the profession.

What Is Wrong in Jersey?

For nearly thirty years the engineers of New Jersey appealed to and demanded of the legislature at Trenton a license law for engineers and firemen. Local city ordinances were rightly scorned by nearly all and each year renewed effort was made to make the law a reality, for state supervision of this matter was deemed best and proves best wherever practiced. Its industrial importance made a state license law imperative in New Jersey, and thanks to the unremitting efforts of the engineers the legislature passed, though reluctantly, the last bill presented.

This law took effect on July fourth of last year—fifteen months ago. The law required that within sixty days after its enactment the Commissioner of Labor should organize a steam engineer's and boiler operator's license bureau. About July first of last year it was rumored that, as the bill passed during the closing hours of a special session of the legislature, no appropriation had been made, to carry out the provisions of the law, and therefore the bureau would not be organized until an appropriation was forthcoming.

Months later, on the reassembling of the legislature, the appropriation came and all that remained to be done was for the Commissioner of Labor to appoint the personnel of the bureau and have his appointments confirmed by the civil service commission. In the meantime, Commissioner Bryant was subjected to attack by politicians who wished to rob him of his powers. The attack was iniquitous and his friends, the engineers, publicly voiced their disapproval of the whole affair, and with their support and that of the press, Col. Bryant retained his department.

In view of this, there is a feeling of deep dissatisfaction among the engineers at the recent action of the Commissioner. He made the appointments, but he is insisting too strongly on playing a political game unbecoming his office to force his appointments through after two out of the three appointees have fallen "considerably below the usual passing mark" in their examination before the civil service commission.

Commissioner Bryant appointed three men, each representing one of the three leading engineering organizations in the state. Mr. Case, who acted as chairman for the license committee for the National Association of Stationary Engineers in New Jersey, was the only one to pass, and engineers are wondering if they must wait until the commissioner railroads the other two through, despite their failure to qualify, before the bureau begins its work. There are many engineers qualified for these positions who have the time necessary to give to the work. Let the commissioner select from among these before the legislature repeals the law at the coming session, as there is some talk of doing.

⁂

If the American Society of Mechanical Engineers' Code for boilers comes into general use, it will be possible to tabulate and classify quite completely, for all will be 55,000 pounds tensile strength.

⁂

Maximum efficiencies to the engineer are like the fixed stars to the mariner; though neither can be touched, they are invaluable as guides to the right way.

Correspondence

Incompetent Repair Men

In almost every community there is the usual repair shop where it is alleged that all kinds of machines are repaired by expert mechanics with neatness and dispatch. All too frequently these shops must be called upon by the engineer who does not even have a pipe cutter or die. Some of their blundering mistakes are ludicrous, to say the least.

In a certain small plant the engine was a 14x36 simple Corliss with V-guides. The engineer had the lower crosshead shoe rebabbitted at the repair shop, but the repair man accidentally dropped it on the cement floor, breaking off the lug for the adjusting screw.

He did not acknowledge the accident or take steps to make repairs, but in slipping the shoe into place he used a large washer under each jamb nut, by which the shoe was adjusted. As the crank side of the engine was near the wall on the dark side of the room, the missing part was not noticed for several weeks. The repair shop refused to furnish a new shoe for the one broken.

Some years ago I was engaged as engineer at a plant after this same shop had been doing some work there. The coal consumed was much more than before, and the engineer, of course, was held accountable for the excess. The engine seemed to be working under difficulties and on Sunday, when the steam-chest cover was removed, the cause was apparent. The engine was a 15x30-in., having one of the old-style slide valves. The steam ports were short and direct and there was an exhaust port cored in at each end beside the steam ports which led down to one common exhaust opening under the cylinder.

Thus, there were two slide valves, one for each end of the cylinder, tied together by two heavy tie bolts having right- and left-hand threads to permit the necessary adjustment. Each of these valves had a long lap on the steam side and a short one on the exhaust, but when the repair man reassembled the combination, he put the crank-end valve at the head end, and *vice versa*.

This gave the engine practically no steam lap, while the exhaust lap was excessive, though the engine continued to run it required considerably more steam than before. The back pressure was excessive, and about all the jet condenser could do was to condense the steam without producing a vacuum. When the valves were put in their original position and squared up, and the eccentric advanced, the engine once more ran with its usual ease and quietness, while the fuel was nearly as much lower than before the engine was overhauled as it was higher right after the repair man left the job.

On another occasion a vertical 10x12 engine, directly connected to a centrifugal pump, ran up to speed empty, but with a sharp exhaust. As soon as the load came on, though, the speed was so reduced that the pump ceased to discharge water. On removing the steam-chest cover, it was found that the eccentric had been so set that, with the engine on the center, the valve had the necessary amount of lead but it was closing instead of opening, and real admission did not take place until the piston had advanced to about half stroke. The only adjustment necessary was to set the eccentric properly.

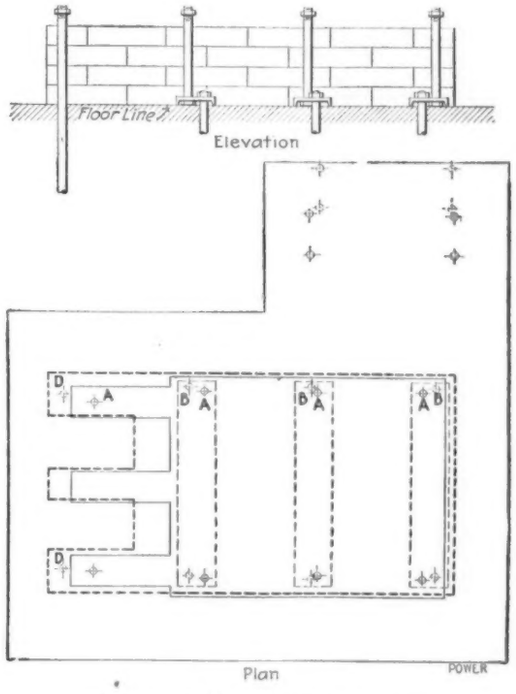
A man may be an excellent machine or bench hand and be entirely ignorant of the fitness of things pertaining to power-plant machinery.

GEORGE H. WALLACE.

Racine, Wis.

New Engine on Old Foundation

Owing to increasing the load, it was necessary to take out an old gas engine and put in a new one of larger size. The holes in the bedplates were made to a different templet and some changes had to be made in the anchor bolts The old brick foundation was raised about 17 in. above



OLD AND NEW FOUNDATIONS

the floor line. The illustration shows the difference in the templets, the full lines showing the old and the dotted lines the new one; *A* refers to the old bolts, and *B* to the new.

The following method was used to fasten the anchor bolts for the new engine. The old foundation was taken down to the floor line, and the anchor bolts cut off about 3 in. above and threaded. Three pieces of 2x8-in. channel iron were drilled for the old and new bolts.

Concrete was then poured on the old foundation and the channel irons laid in position in it, over the old bolts, with the new bolts in their respective holes. The

nuts on the old bolts were then pulled down tightly, the new templet placed over the upper ends of the new bolts, and the new foundation built around them.

The two rear bolts *DD* came in the old exhaust pit, so the rear of the new foundation was built up from the bottom of the exhaust pit with these two bolts anchored as usual. Part of the foundation for the outboard bearing had to be rebuilt, so that two of the bolts could be built in the new part, holes were drilled in the old part for the other two bolts to be grouted in.

The new engine sets as solidly as if the foundation had been built up new all the way from the bottom.

EARL PAGETT.

Coffeyville, Kan.

Precaution against Water in Receivers

In operating compound engines, especially those having receivers between the cylinders, great care should be exercised to see that the receiver pressure exceeds that of the atmosphere.

There have been numerous wrecks of low-pressure cylinders (some of them classed as "mysterious") caused by the operators allowing the receiver pressure to get low during periods of light loads and the receiver trap not operating on account of excessive discharge resistance. Considerable water would accumulate in the receiver, and then when the load increased the water was thrown into the low-pressure cylinder.

The remedy is to always keep the receiver pressure higher than that of the atmosphere. This can be done on some engines by shortening the cutoff to the low-pressure cylinder, but if the engine is not equipped with a hand-regulating apparatus, the pressure should be kept up by admitting live steam to the receiver. Some engines are equipped with a combination vacuum and pressure trap which, if kept in good working order, should obviate any danger.

JOHN F. HURST.

Louisville, Ky.

Commutator Lubrication

A. G. Curren says, in the June 9 issue, that a little vaseline or engine oil on a rag is a good commutator lubricant. That is true in some cases, but there are times when other methods of lubrication must be applied. In fact no two commutators require exactly the same treatment, according to my observation. For instance, in the plant where I am employed there is one generating set that has been in almost daily operation for six years, and during that time the commutators have never been turned down and, to my knowledge, they have never indicated in any manner that they were in need of lubrication. On the other hand, in the same room there is another set working under entirely different conditions. The commutator speed is much higher, and because of the work it performs the commutator becomes quite warm. Vaseline, paraffin, oil and everything else that we thought would prove beneficial, were tried on these commutators, but the results were not satisfactory. What lubricant there was in the brushes when new would soon break out and from then on we were continually applying something to the commutator in an effort to reduce the noise and cutting.

Finally, in the September 26, 1911, issue of POWER was published a letter from Mr. Johnson, in which he told of using a piece of flax packing as a commutator lubricant. That idea has saved us much trouble with this particular machine, a booster for charging batteries.

By laying a piece of flax packing on the commutator it is lubricated and the brushes also absorb some of the oil. This we have proved by taking the flax off after several hours' run, after which the machine would then run quietly for a while without requiring further commutator lubrication. After a piece of flax has been used for some time it will, of course, become dry. We have found that kerosene is the best thing with which to moisten it. The use of kerosene is especially valuable on a commutator having a tendency to run to high mica, as the kerosene softens the mica and causes it to wear down as fast as the bars.

H. G. GIBSON.

Washington, D. C.

Conserving Niagara

Your editorial on the above subject, in the Aug. 11 issue, prompts me to suggest the following compromise: Why not utilize the water for power purposes six days and nights a week and let the water flow over the falls on Sundays for the benefit of the tourists?

F. F. PHYVESENTZ.

East Orange, N. J.

Heat for Beginners

In his article on "Heat, a Lecture for Beginners," in the Aug. 4 issue, Mr. Bromley seems to fall into the error of giving definitions that tend to confuse the practical man.

Quoting from his third paragraph, we have:

> Pressure, of course, has a great deal to do with heat and temperature as related to water. Suppose we had the 1 lb. of water under 400 lb. absolute pressure; that is, the pressure indicated by the gage plus the atmospheric pressure, or 15 lb. The temperature would be 444.8 deg. F. The pound of water would contain 1208 B.t.u. at this temperature.

The fact that 1 lb. of water is placed under 400 lb. pressure would not cause its temperature to be 444.8 deg. F., or any temperature other than that which it had before being placed under pressure.

Furthermore, pressure has nothing to do with heat and temperature as related to water, that is, the same amount of heat is required to raise water 1 deg. F., regardless of the pressure on the water.

Mr. Bromley quite evidently did not intend to convey the idea this part of his article would lead one to conclude. His meaning is clear enough to one who is acquainted with the subject, but to a beginner it is likely to be confusing.

L. H. MORRIS.

Waco, Texas.

Mr. Morris' criticism may be true as applied to a very few readers. As some readers may misinterpret the article, or at least that part of it to which Mr. Morris refers

I hasten to reply. The introduction stated that the article treated of heat chiefly as related to boiler practice. Any man about the plant knows from observation that water may be under high pressure and still not be hot—for instance, the water in a hydraulic elevator system. Any fireman knows, when he pumps cold water into a boiler preparatory to a hydrostatic test, that when the pressure reaches 100 lb., the water does not have a temperature corresponding to 100 lb. steam pressure. Even the housewife knows that she cannot get hot water from the cold-water faucet, although the city water pressure may be 80 lb. per sq.in. Such facts would indicate that but few have misunderstood the author.

New York City. CHARLES H. BROMLEY.

Direct-Current vs. Three-Phase System

In the Aug. 11 issue, pages 211 and 212, E. M. Marshall compares the three-wire direct-current system with the three-wire, three-phase system. It is evident that he is in error in his computations regarding the copper requirements of the system. If the two-wire system at 110 volts is assumed to require 100 per cent. copper, the three-wire system at 220 volts will require 37½ per cent., all three wires being the same size, while the three-phase system will be 50 per cent. instead of 75 per cent., as Mr. Marshall states. This is evident from the following:

If I equals the current for the two-wire system, the current for the three-wire system will be I/2. Hence the copper required for each wire will be in proportion to the square of this, or ¼ the copper required for each wire in the two-wire system. With the three wires, the total requirement will be ⅜ for the three-wire system, or 37½ per cent. Similarly, in the three-phase system, the current will be equal to $\frac{I}{\sqrt{3}}$, so that the copper required in each wire will be equal to ⅓ of that for each wire in the two-wire system. Hence, the total requirement will be one-half of the two-wire, or 50 per cent., instead of 75 per cent. as stated.

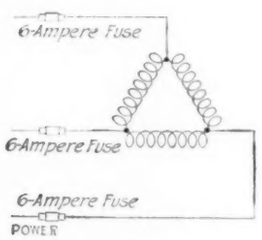


FIG. 1. CUTOUTS AS ARRANGED ON THREE-PHASE CIRCUIT

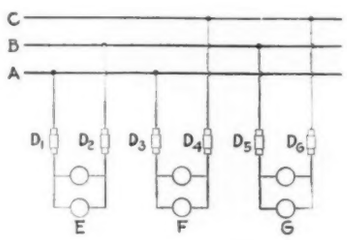


FIG. 2. LIGHTING CIRCUITS FROM THREE-PHASE SYSTEM

Mr. Marshall's conclusions regarding the watts allowed by the Underwriters in the three-phase system, are somewhat erroneous, for it is manifest that Rule 23, Section "d" of the Underwriters' rules requires that not more than 660 watts shall be dependent upon one cutout, and it is manifest that in the three-phase system as shown in Fig. 1 there are three cutouts on which the circuit is dependent and that the opening of any one will not cut current entirely off the circuit. Hence, the Underwriters have allowed currents of 6 amperes in the main branches of circuits wired as in Fig. 1, or a total of 1147 against 1320 watts as allowed in the three-wire, direct-current system, or 86 per cent. as Mr. Marshall stated. However, it is seldom that lighting is done on three-phase circuits according to this method of connection, and

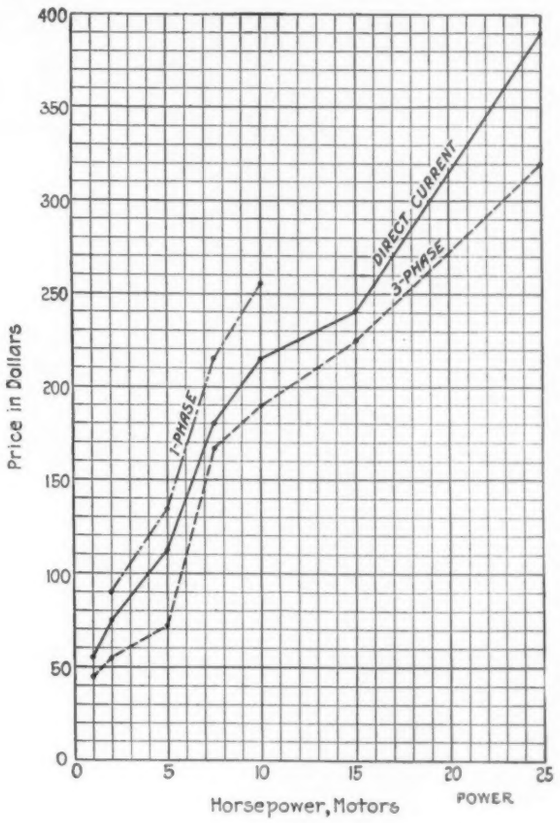


FIG. 3. RELATIVE COSTS OF DIRECT- AND ALTERNATING-CURRENT MOTORS

the 660-watt rule does not apply to polyphase motors where such a method of connection is ordinarily used. The accepted method of operating lights from a three-phase circuit is as shown in Fig. 2, where A, B and C are the mains and the lighting circuits are at E, F and G, with cutouts at D_1, D_2, D_3, etc. Hence, each of the three circuits E, F and G may carry 660 watts, or a total of 1980 watts, or 50 per cent. more than that allowed in the direct-current, three-phase system advocated by Mr. Marshall.

Moreover, he has failed to mention the real points which usually decide in favor of the alternating-current system, namely, the greater simplicity of the motors and the greater distance to which the alternating current can be transmitted and the possibility of purchasing central-station power for breakdown service.

I wish also to take exception to Fig. 3 in Mr. Marshall's paper showing the relative costs of direct- and alternating-current motors. These are shown by straight lines, which is manifestly inaccurate, as motor prices do not vary according to straight-line curves. I submit herewith curves, Fig. 3, showing relative prices of three-phase direct-current and single-phase motors, as taken from the price forms of a large motor manufacturer. It is to be noted that the prices will depend entirely upon the speed, and it is, of course, impossible to compare prices

unless the speeds are approximately the same. This has been done in the present case. All the motors up to and including 5 hp. are at 1700 r.p.m., and those above this size are 1150 r.p.m. It will be noted that the single-phase motors are consistently higher than the direct-current motors, and that the direct-current motors are higher than the three-phase motors. There is no crossing of the prices as indicated by Mr. Marshall, so that three-phase motors are consistently lower in all sizes than either direct or single-phase motors, and direct-current motors are always lower than the single-phase motors.

S. A. Fletcher.

Pittsburgh, Penn.

Joining Broken Lead Pipes under Pressure

It frequently happens that lead pipes conveying water at high pressure are cut or damaged, causing much trouble to make repairs, especially if the water cannot be turned off readily. In this case, cut the pipe at the leak, plug both ends and place a small pile of broken ice and salt around them. In a few minutes the water in the pipe will freeze. Then withdraw the plugs and solder in a new piece of pipe. After thawing the ice, the job will be all right.

Paul Nordstrom.

Hadley, Alaska.

Supporting the Designer

It has been correctly stated, that unless the designer of a power-plant or engineering structure has the full support of his employers to the extent of carrying into effect a logical, consistent and safe design, it were better he resign and save himself much humiliation. A man competent to design power plants should not temporize on a subject involving the success and perhaps the safety of the design. Unless he has the authority to insist upon the execution of a proper design, it would be better he quit, for it is almost certain he will be held responsible for whatever design is adopted.

The faulty breeching connection described by Mr. Park in the Sept. 1 issue (page 316) calls to mind the experiences of a designer who was engaged in the reconstruction of a cement plant. One of the jobs was the remodeling of the boiler plant. Although the designer was fully competent he had no authority and did not receive the support due him, and while his drawings and specifications may have been correct, there was no assurance that the work would be done accordingly. An instance in point was in the construction of some foundations for machinery. Happening to come up while the concrete was being placed, he found that the aggregate, which was being measured by wheelbarrows, was of such amount as to produce a 1 : 3 : 9 mixture where a 1 : 3 : 5 was required, and the broken stone contained 30 per cent. of dirt. Protesting against such construction, the designer was branded as "finnicky" and over particular.

The boiler-house stack and breeching as used in the old plant were found insufficient for the needs, and a new stack and breeching were installed of ample capacity. While the stokers were being installed, and previous to the rebuilding of the setting, the designer left, which fact did not save him from being criticized as being responsible for the poor detail at the uptakes (exactly as described by Mr. Park), although he left instructions how to proceed. It would seem improbable that a designer would lay out the stack and breeching of ample capacity, and then fall down on so obvious a thing as the necessary area around the drums at the uptake.

C. O. Sandstrom.

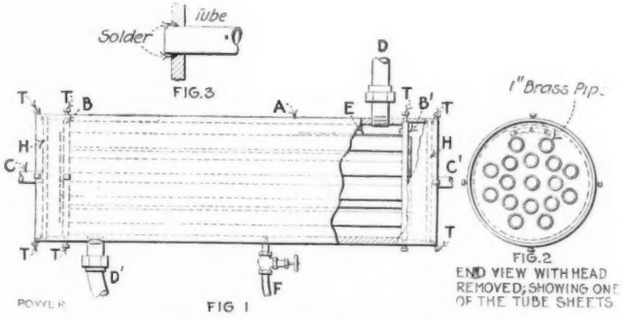
Kansas City, Mo.

Home-Made Feed-Water Heater

In a New England hotel plant, the feed water was kept at an average of 110 deg. F., and as the plant was equipped with some modern machine tools, including a 16-in. lathe, it was decided to build, without outside help, the feed-water heater shown in Fig. 1.

The body *A* was a piece of 12-in. cast-iron pipe 3 ft. 6 in. long. The tube sheets *B* and *B'*, also cast iron, were made a driving fit against the shoulders, and further secured by the setscrews *T*.

The holes in the tube sheet *B* were countersunk, and when the tubes were in place, the cavities were filled with solder, Fig. 3, so that the tubes were firmly secured at one end. In the other tube sheet *B'*, the tubes were made a neat fit, and when the heater warmed up, the coefficient of expansion of brass being greater than that of iron, a steam-tight joint would be formed, and at this same time, allow for the tube expansion and contraction.



Construction of Heater

The two cast-iron heads *HH* were held in place by setscrews as shown, and a rubber gasket between the heads and the shoulders insured a tight joint. Water passed in through *C* and out through *C'*. The steam inlet was at *D*, exhausting through *D'*. A baffle-plate *E*, secured to the tube sheet *B'*, protected the upper tubes from the impinging steam.

It will be noticed that the steam inlet was piped in close to the tube sheet *B'*, thus warming up the tubes at that end before the water was turned on and forming the steam-tight joint.

The drain *F* leading to the feed tank was kept open while the heater was in operation. The feed water entered the heater at about 110 deg. and left at an average of 200 deg. F.

These figures will give an idea of how much coal was saved:

Average consumption of feed water per hr. = 34,500 lb.
B.t.u. saved per hr. = (200 — 100) × 34,500 = 3,105,000.
Equivalent amount of coal saved per hr. = 3,105,000 ÷ 13,500 = 230 lb.
Coal saved per 24 hours = 2.76 tons.

Samuel J. Robinson.

Port au Prince, Haiti.

Indiana Boiler Law

The editorial under the above caption in the issue of Aug. 28, mentions some of the defects in the Indiana boiler law. There is, however, another section not mentioned which, I believe, makes a dangerous condition possible. It is as follows: "Sec. 17. On all steam lines there must be a cutoff valve placed in the steam pipe not farther than 18 in. from the boiler shell."

"On all boilers installed on and after July 1, 1913, where two or more boilers are connected to the same steam line or main, the branch pipe to each boiler shall be provided with two stop valves, one to be placed near the steam main and the other not farther than 18 in. from the shell of the boiler. In water-tube and all boilers carrying 100 lb. steam pressure or over, an automatic shutoff valve must be placed between the boiler and stop valve."

Fig. 1 shows a connection that conforms to the first paragraph; Fig. 2, the construction required by the second paragraph with a valve within 18 in. of the boiler and and one near the header. The law does not require a drain valve in either case. If the boiler is to carry over 100 lb. pressure there must be an automatic shutoff valve between the boiler and the stop valve. This would either require three valves, or the substitution of the automatic valve for one of the stop valves, which is practicable. Fig. 3 shows the same kind of connection where the head room is limited, and the branch must be nearly horizontal.

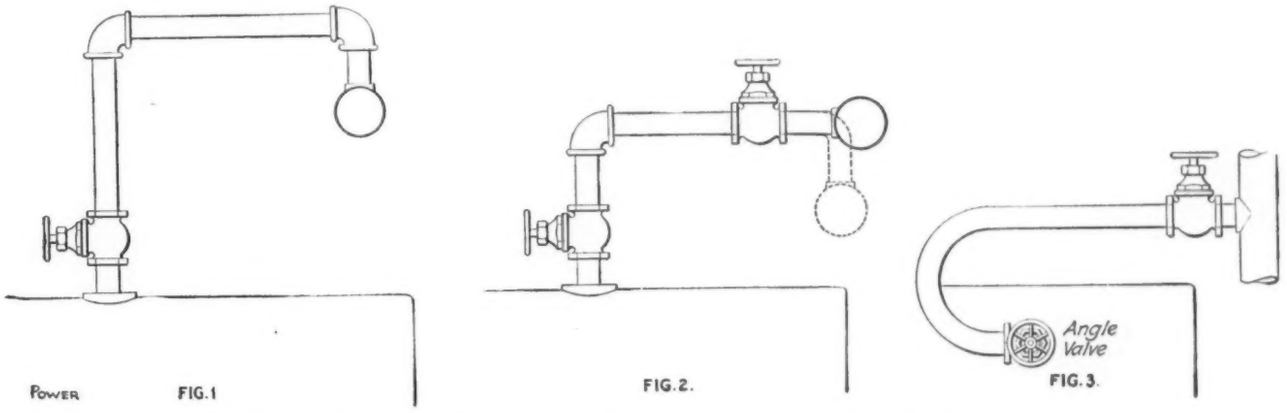
If a drain pipe is connected above the valve and used properly every time the boiler is put into service, there is but little chance for damage from water-hammer. Safety laws are made to eliminate dangerous conditions so far as possible, but if they do not prevent dangerous construction or operation, what are they good for? Since the law in question does not require a drain, a contractor would be within the law in omitting it.

For several years, I had charge of a plant with the boilers connected as shown in Fig. 1, with a drain valve just above the stop valve. On one or two occasions the drain was not opened, and from the noise of the water-hammer, I thought that a boiler had exploded.

In another case, a horizontal branch had a valve on each end, but no drain; the stop valve on the boiler was burst by water in the line. Water-hammer is dangerous. Every means should be taken to prevent it and the piping so arranged that no pockets of water can be formed. This would do away with the necessity for hand drains, traps or other arrangements which depend on the operator, and the cost of construction need be no greater. The piping as shown might be operated for years without trouble but, some time, one might lose his life from improper operation of the valves. The law should be so amended that it will eliminate the possibility of water-hammer at this point. In boiler plants already installed, traps and drains may be permissible, but all new work should be self-draining. This cannot be done under the present Indiana law.

J. C. Hawkins.

Hyattsville, Md.



Three Types of Connections Permitted by the Indiana Law

Vacuum Ash-Handling System

As quite a number of plants in this country use the vacuum ash-handling system, the following points obtained from several years' experience may be of interest:

One system at first had no dust collector; it was put in later, only to be taken out as the fine ash mixed with moisture clogged up all the openings in the separator, causing its collapse. The manganese wearing backs of the elbows last about three months by turning them end for end after six weeks' wear. The extra-heavy steel ash pipe, fitted with standard flanges, flush and faced at the ends, would last six months on a horizontal run if it were turned one-half way around after three months' wear, so as to expose a new surface to the action of the ash.

Cleaning red ash out of the combustion chamber is difficult, and can be done only by mixing with the hot furnace ash.

After two or three years' use in handling 20 tons of ash daily, the exhauster blower will begin to depreciate in efficiency, due to the wearing action of the ash dust. The life of the blower can be prolonged a year or two by using a dope of fireclay, old pulverized magnesia pipe covering and a cheap axle or cup grease. This mixture is admitted to the suction side of the machine, as closely as possible while it is in operation, so that it will fill the unduly worn clearance spaces.

At times the fine ash dust will so choke the machine as to render its operation impossible. Then a liberal use of kerosene in the suction will remedy matters, after which it will be necessary to use more of the mixture.

I have found it advisable to remove the suction nozzle from the machine once a year because it fills with a de-

posit that interferes with the capacity unless removed. On account of the comparatively low vacuum carried on the system it is hard at times to locate such troubles by gage testing.

A few years ago, after the first system of piping showed signs of wear, it was concreted, using the pipe as the internal form. This pipe lasted about a year, with a lot of patching, but it had to be replaced. The work entailed in removing the concrete offset any advantage that could be gained by its use.

Louisville, Ky. JOHN F. HURST.

Trouble with an Air Lift

We have a 6-in. well 326 ft. deep. The water comes within 30 ft. of the top and we use an air lift for raising it. The end of the 1-in. air line was plugged, and in about 3 ft. of it there were drilled $\frac{1}{16}$-in. holes. This pipe extended 136 ft. into the well.

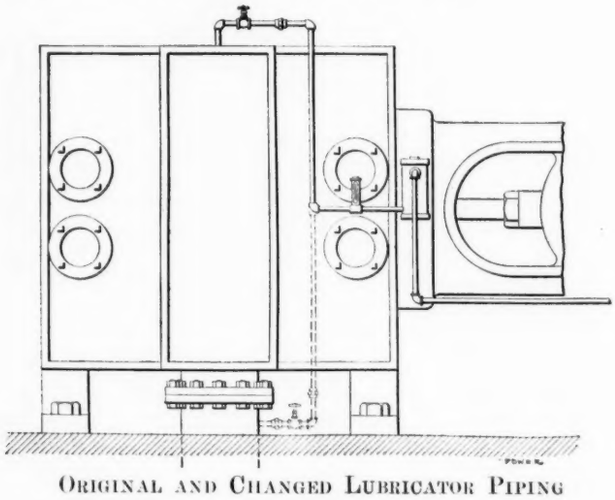
The pumps were run only long enough to fill the tanks, but one evening we failed to get water. Usually, 60 lb. of air was sufficient, but 80 lb. failed to raise it, and this was the limit of air pressure we could get.

We pulled the air line out and found the perforated section entirely covered with lime. All new pipe was then put in and about 36 ft. added. The holes in the perforated section were made $\frac{1}{8}$ instead of $\frac{1}{16}$ in. I would like to know if this is a common occurrence, as it is the first time it has happened here. The well had not been opened in 14 years before this.

Julietta, Ind. ARTHUR V. LACY.

Faulty Engine Lubrication

A new high-speed, four-valve engine was recently installed in a Washington plant. The engine was given a factory test before shipping, the cylinder lubricator connections were left intact when the engine was shipped and the oil pipe from the lubricator entered the valve chest on top, as shown by the full lines in the sketch.



ORIGINAL AND CHANGED LUBRICATOR PIPING

The engine was assembled and started up, but trouble was had from the first by the seeming inability of the valves to get enough oil. After a few weeks' run they were found so badly cut in places that they were returned to the factory, their appearance warranting the belief that plenty of oil was getting to them but that it was not being properly distributed.

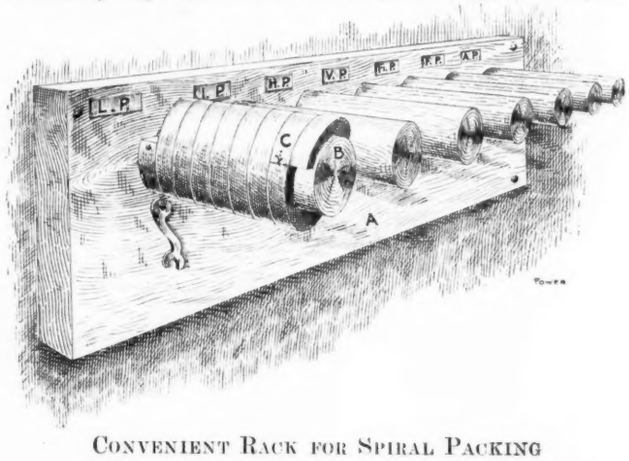
It was then decided to introduce the oil into the steam pipe at the point shown in the sketch by the dotted lines. This was done on the theory that the oil would have more opportunity to mix with the steam before reaching the valves, thus obtaining better distribution. To aid the mixing of the oil with the steam the pipe extending into the steam pipe was perforated with small holes and plugged at the end.

The results of the change, after several months' trial, are satisfactory, with no more trouble in securing a distribution of oil over the interior surfaces requiring lubrication.

Washington, D. C. H. G. GIBSON.

Rack for Packing

Engineers and oilers sometimes have trouble when new packing is needed at once on the piston rods of pumps or engines. Some piston packing comes in spiral form and is usually kept loose in a box or in a bench drawer, all



CONVENIENT RACK FOR SPIRAL PACKING

mixed together. When a few rings are required in a hurry the proper size cannot be readily found; it is generally at the bottom of the tangle.

A rack board, made as shown in the illustration, was found convenient for the purpose. Holes were bored in a 2x4-ft. board *A*, and wooden pins driven into them. The pins were turned to compare with the diameter of the different engines and pump piston rods. Above each stud a label was pasted to indicate the nature of packing.

The packing was wound around the pins, as shown, with the inner end fastened to the stud. When a ring was required it was only necessary to twist the packing tight on the pin and cut as shown by the dotted line *C*, with an allowance for taking up with the glands.

To render this easier and have a standard length in packing rings, the wooden studs were turned a trifle smaller in diameter than the rod in question to allow for the expansion of the packing. This difference varies for different packing and sizes, and can be tried out on the rod itself.

Under each packing pin the wrench is hung for the gland nuts of that particular size packing. The pins can be arranged as shown, with the larger diameter packing first, and so on down to the smallest size.

New York City. J. A. LUCAS.

Inquiries of General Interest

Overload of a Boiler—What is meant by operating a boiler with 25 per cent. overload?

W. S. H.

That the evaporation is 25 per cent. in excess of the rated capacity of the boiler.

Calorific Value of Fuel Oil—What is the calorific value of fuel oil?

C. F.

American fuel oil as fired has a calorific value of about 16,000 to 19,500 B.t.u. per lb., varying with the locality and the percentage of water contained.

Feeding and Firing While Blowing Down—What damage would result to a boiler by continuing the firing or running the feed pump while blowing down?

J. B.

There should be no damage resulting to a boiler from continuing the feeding and firing while blowing down.

Shape of Iron Tank Bottoms—Why are the bottoms of iron tanks made conical or hemispherical?

S. W.

For greater strength of the bottom when the tank is supported around the sides, this method of supporting iron tanks being desirable as it admits of ready access to the joints for calking.

Running Smoothly Without Compression—Is it possible for a simple slide valve engine that is making 190 turns per min. to run smoothly without compression of the exhaust?

D. W.

It is possible by obtaining cushioning effect with lead and by having the bearings in good condition and the connecting rod brasses skillfully adjusted.

Water Rate of Turbo-Generator Set—How is the water rate per kilowatt-hour of a turbo-generator set determined?

E. C. S.

The water rate is usually found by determining the weight of the condensate of the steam used during a stated period and dividing the number of pounds per hour by the actual kilowatt output per hour during the same period.

Crushing Strength of Plate—In formulas for strength of riveted joints, what is meant by "crushing strength of plate?"

E. W. S.

The term "crushing strength of plate" refers to the strength of the material to resist crushing from the compressive force which results from transmitting a shearing stress to the rivets.

Designating the Degrees of Elbows—As 45 deg. is only one-half of 90 deg., why is a 45-deg. elbow so called when the actual angle of the elbow is 90 + 45, or 135 deg.?

G. K.

Elbows are designated according to the number of degrees which they deflect a pipe line from a straight line, and not by the number of degrees contained by the angle of their axes. There are thus 30-, 45-, 60- and 90-deg. elbows. A coupling would be 0, and a return bend is often designated a 180-deg. elbow.

Preserving Proper Length of Connecting Rod—In taking up the wear of connecting rod brasses, what must be done to keep the rod the proper length?

F. K.

In taking up the wear, the rod becomes longer or shorter according to the method employed for tightening the brasses and to compensate for the reduction of the thickness of the brasses from wear, and preserve a length of rod which will give proper clearance between the piston and ends of the cylinder, shims consisting of thin sheets of metal are to be placed behind the brasses.

Effect of Advancing Eccentric—What effect has advancing the eccentric on the power that can be developed by a single eccentric Corliss engine?

V. K.

With normal adjustment of the valve gear, it has the effect of reducing the power which the engine is capable of developing, as advancing the eccentric shortens the maximum cutoff at which the valve-gear can operate, hastens the release by earlier opening of the exhaust and increases compression by earlier closure of the exhaust, all of which reduce the maximum m.e.p. capable of being developed with a given initial pressure.

Placing Engine on Center by Leveling vs. Tramming—Which is the more accurate method of placing a horizontal engine on a dead center, by applying a machinist's level to one end of the connecting rod, or by tramming?

J. F. F.

The method of tramming is more accurate, because accuracy in determination of the dead center by use of a level depends on truthfulness of level of the center of the shaft with the crosshead pin, parallelism of connecting rod center line with the part of the connecting rod which is used to support the base of the level, the accuracy and sentitiveness of the level, and personal error in observing the indications of the level bubble, any of which is more likely to be a source of greater error than the accumulation of errors from ordinary care in determining the dead center position of the crankpin by tramming.

Height of Injector or Siphon Condenser—Why must an injector or siphon condenser be 34 ft. above the level of the tail water?

L. A. H.

The height of the column of water between the condenser and hotwell, or tail water, must be as great or greater than that which atmospheric pressure will support with a given vacuum, so that the constant supply of condensing water will produce a continuous downward flow. With a perfect vacuum, atmospheric pressure will support a column of "solid" water nearly 34 ft. high and higher if the water is rarified by the presence of air. To insure a continuous downward discharge of the condensing water and to prevent it from being carried over to the exhaust with a perfect vacuum, the condenser must be placed at least 34 ft. above the level of the hotwell or tail water.

Size of Steam Pipe—Neglecting drop in pressure due to friction or condensation and allowing a velocity of 5000 ft. per minute, what diameter of pipe would be required to supply 6500 lb. of steam per hour at a gage pressure of 70 lb.?

M. S.

The volume of a pound of steam at 70-lb. gage pressure or

$$70 + 14.7 = 84.7 \text{ lb. absolute,}$$

would be between the volume of a pound of steam at 84 lb. per sq.in. absolute and 85 lb. absolute. According to Marks and Davis steam tables, the volume of a pound of steam at 84 lb. absolute is 5.22 cu.ft., and at 85 lb. absolute the volume is 5.16 cu.ft. Interpolating between these values, the volume of a pound (wt.) of steam at 84.7 lb. absolute is found to be

$$5.22 - [(5.22 - 5.16) \times (84.7 - 84)]$$

or

$$5.22 - (0.06 \times 0.7) = 5.178 \text{ cu.ft.}$$

To supply 6500 lb. per hour would require a flow at the rate of

$$\frac{6500}{60} = 108.33 \text{ lb. per min.}$$

or

$$108.33 \times 5.178 \text{ cu.ft. per min.,}$$

and the cross-sectional area of a pipe required for that flow with a velocity of 5000 ft. per min. would be

$$\frac{108.33 \times 5.178}{5000} = 0.112 \text{ sq.ft. or } 16.13 \text{ sq.in.}$$

Hence the size of the pipe should be

$$\sqrt{\frac{16.13}{0.7854}} = 4.53 \text{ in. diameter,}$$

or practically a 4½-in. steam pipe would be required.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXIX

LAST LESSON'S ANSWERS

131. In equation (78) it was shown that the acceleration with which a point is drawn toward the center of a rotating body is $\frac{V^2}{R}$, where V is the linear velocity of the point, located R feet from the center of rotation. In this case the linear velocity of a point on the rim of the wheel is $2 \times 3.1416 \times 5 \times 100 = 3141.6$ *ft. per min.* or 52.36 *ft. per sec.*, since the radius of the rim is 5 ft. Therefore, the acceleration is

$$a = \frac{(52.36)^2}{5} = 548.3 \text{ ft. per sec. per sec.}$$

132. The weight of the rim may be found by the method explained in problem (128), thus

$$W = \frac{8 \times 10 \times 351.9}{1728} \times 450 = 7330 \text{ lb.}$$

The weight per inch length of rim is equal to the total weight of the rim divided by the circumference of a circle whose diameter is the mean diameter of the rim. Let w = the weight in pounds per inch length of rim, then $w = \left(\frac{7330}{351.9}\right) = 20.8$ *lb.*, and the centrifugal force per inch length of rim is $\frac{wV^2}{gR}$, where V is the linear velocity of the point, located R feet from the center of rotation, and equals

$$3.1416 \times (9\tfrac{1}{3} \text{ ft.}) \times \tfrac{100}{60} = 48.87 \text{ ft. per sec.}$$

Therefore the centrifugal force per inch of rim is

$$\frac{20.8 \times 48.87 \times 48.87}{32.16 \times (4\tfrac{2}{3} \text{ ft.})} = 331 \text{ lb.}$$

133. The pressure on the bearings is equal to the centrifugal force of the unbalanced weight of 5 lb. From equation (79) the centrifugal force is $\frac{WV^2}{gR}$, where W = 5 lb.; V = the velocity of the weight in feet per second $= \frac{1500}{60} \times 3.1416 \times 3 = 235.6$ *ft.* and R = the radius of gyration = 1.5 ft. Therefore, the centrifugal force is

$$C = \frac{5 \times 235.6 \times 235.6}{32.16 \times 1.5} = 5753 \text{ lb.}$$

which gives the excess pressure on the bearings. This high speed was assumed to show the great strain that comes on the bearings supporting a shaft that holds an unbalanced wheel of any sort.

134. Assume only the weight of the balls A and B. In Lesson IV, Fig. 15, it was shown that there are three forces acting on the ball A, and, as these forces are in equilibrium, they may be represented by the sides of the triangle $EFGE$, Fig. 82, where the side EF is the weight of the ball; the side GF the centrifugal force C; and the side GE gives the tension in the supporting link. This force triangle has its sides respectively parallel to the triangle $OMAO$, Fig. 81, and therefore the two triangles are similar. Hence

$$\left(\frac{\text{centrifugal force } C}{\text{weight } W}\right) = \left(\frac{\text{side } AM}{\text{side } OM}\right) = \frac{R}{H}$$

and as $C = \frac{WV^2}{gR}$, it follows that

$$\frac{\left(\frac{WV^2}{gR}\right)}{W} = \frac{R}{H}, \text{ or } \frac{V^2}{g} = \frac{R^2}{H}$$

This equation shows that, *neglecting the friction*, the action of the flyball governor is independent of the weight of the ball. The velocity $V = 2 \times 3.1416 \times R \times N$ *ft. per sec.*, where N = the revolutions per second, hence,

$$\frac{(2 \times 3.1416 \times R \times N)^2}{32.16} = \frac{R^2}{H} \text{ or, } N^2 = \frac{0.815}{H}$$

But $H = OA \cos 30$ *deg.* $= 1.5$ *ft.* $\times 0.866 = 1.299$ *ft.* Therefore,

$$N^2 = \frac{0.815}{1.299} = 0.63 \text{ or } N = 0.79 \text{ rev. per sec.} = 47.4 \text{ r.p.m.}$$

135. If the angle OAM is 20 deg., then $H = 1.5 \times \cos 20$ *deg.* $= 1.5 \times 0.94 = 1.41$ *ft.* and

$$N^2 = \frac{0.815}{H} = \frac{0.815}{1.41} = 0.58, \text{ or } N = 0.76 \text{ rev. per sec.}$$
$$= 45.6 \text{ r.p.m.}$$

The reduction in speed = (47.4 — 45.6) = 1.8 r.p.m.

MECHANICS OF BELTING

One of the common questions raised in the power plant and in the shop is: What size belt shall be used to transmit a given horsepower? This may be answered by the application of the principles of mechanics outlined in the previous lesson. Thus the force of friction between two bodies is dependent upon the normal pressure and the coefficient of friction. In the case of a belt this force of friction tends to change the tension in the two sides of the belt.

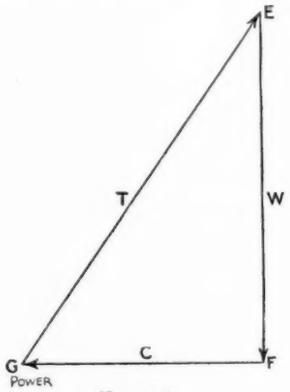


FIG. 82

In Fig. 83, if a belt be stretched over the two pulleys A and B (assumed idle) and spring balances be placed on the top and bottom sides of the belt it will be found that these balances will register approximately the same tension I. Now if the pulley A be put in motion, it is a matter of experience that the lower or driving side of the belt will tend to lengthen and as a result the upper side will become slack. Stated in other words, the tension in the driving side increases and the tension in the slack side decreases. This difference in the tensions is due to the force of friction acting between the belt and the face of the pulley. In Fig. 84 let the pulley A be the driver and the pulley B the follower. Let T_1 be the tension in

the tight or driving side of the belt and T_2 be the tension in the slack side. Let a = the arc of contact between the belt and the face of the smaller pulley B, expressed in radians; and let f = the coefficient of friction of the belt. By the aid of higher mathematics, it may be shown that the relation between the tensions of the tight and slack sides of the belt is expressed by the equation

$$log_e\left(\frac{T_1}{T_2}\right) = f \times a \qquad (81)$$

where e is the Naperian base of logarithms. This equation may be expressed in simpler form by changing the

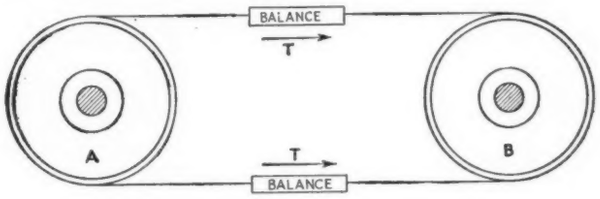


FIG. 83

Naperian to the common logarithm from the fact that the common log. = 0.434 × the Naperian log, hence,

$$log_{10}\left(\frac{T_1}{T_2}\right) = 0.434 f \times a \qquad (82)$$

which may still further be simplified by inserting in place of a radians its equivalent value in degrees. Let N = the ratio of the arc of contact to the circumference of the smaller pulley. If there are a radians in the arc of contact, then $N = \frac{a}{2\pi}$ or $a = 2\pi N$ (since there are 2π radians in the circumference of a circle). This ratio N might also be found by dividing the arc of contact in degrees by 360 (the number of degrees in the circumference of a circle). Now substituting the value of $a = 2\pi N$ in equation (82), there results:

$$log_{10}\left(\frac{T_1}{T_2}\right) = 0.434 \times f \times 2\pi \times N = 2.73 fN \qquad (83)$$

If the distance between the pulleys is large and the diameters are nearly the same, then N will equal approximately 0.5. Under average conditions, the coefficient of friction f will equal about 0.3 so that

$$log_{10}\frac{T_1}{T_2} = 2.73 \times 0.3 \times 0.5 = 0.409$$

and from a table, the value of log $\left(\frac{T_1}{T_2}\right)$ is found to be approximately 2.5. The effective driving effort P, exerted by the belt will be the difference between the tensions in the tight and slack sides or,

$$P = T_1 - T_2 \qquad (84)$$

If the velocity of the belt is V feet per minute, then the work done in foot-pounds per minute will equal $P \times V$ (force times distance) and the horsepower transmitted by the belt will be given by the equation,

$$hp. = \frac{P \times V}{33{,}000} \qquad (85)$$

Example—A single leather belt $\frac{5}{32}$ in. thick is capable of standing about 400 lb. per sq.in., so that for every inch of width a working tension of 400 × $\frac{5}{32}$, or 62 lb., may be placed on the belt. Derive a simple rule for the horsepower transmitted by a single belt.

Solution—Assuming an arc of contact of 180 deg. and a coefficient of friction = 0.3, the relation between T_1 and T_2 will be as previously found, namely, $\frac{T_1}{T_2} = 2.5$, or $T_2 = 0.4\,T_1$. The effective driving effort

$$P = (T_1 - T_2) = (T_1 - 0.4\,T_1) = 0.6\,T_1$$

Now the allowable pull is 62 lb. per in. of width so that the effective pull is

$P = 0.6\,T_1 = 0.6 \times 62 = 37.2$ *lb. per in. width of belt.*

One horsepower = 33,000 ft.-lb. The work done by the belt equals $P\,V$ ft.-lb. per minute so that the velocity required of a single belt 1 in. wide to deliver 1 horsepower must equal $\frac{33{,}000}{37.2}$ or 885 ft. per min.

The above problem is the basis for the commonly accepted rule that *a single leather belt traveling at 900 ft. per min. will transmit one horsepower for every inch of its width*. Theoretically, a double belt will transmit twice the horsepower of a single belt but actually it will only transmit about 1.4 times as much.

STUDY QUESTIONS

136. The distance between the centers of two pulleys, 18 in. and 30 in. in diameter, is 10 ft. Find the arc of contact on the smaller pulley, assuming an open belt.

137. If the coefficient of friction is 0.3, find the relation between T_1 and T_2 in the above problem.

138. If the smaller pulley makes 300 r.p.m., find the horsepower transmitted by a belt $\frac{5}{32}$ in. thick and 12 in.

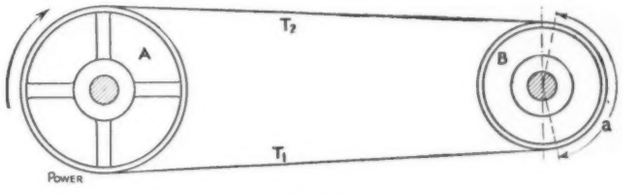


FIG. 84

wide, asuming that the belt is good for 60 lb. per in. of width.

139. A belt is traveling at the rate of 2700 ft. per min. Find by the approximate rule the horsepower transmitted by a single belt 15 in. wide.

140. If a double belt were used, what would be the horsepower transmitted?

A High Boiler Pressure is to be carried on the battleship "Nevada," just launched—295-lb. gage. Oil-fired Yarrow-type boilers will be used.

Electric Welding—It was reported at a recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers that in repairing cracks in the side sheets of locomotive fireboxes a substantial saving had been effected by the use of an electric welding apparatus. The cost of welding forty cracks of various lengths was only $6.65, against an estimated cost of $1400 for replacing the injured sheets.

An Amalgam is an alloy of metals, one of which is always mercury. Mercury has the power of dissolving almost all other metals and mixing with them. It is much used in separating gold and silver from other ores. Among the numerous amalgams are: Tin amalgam, for silvering mirrors; gold and silver amalgam, for gilding and silvering; cadmium and copper amalgam, used in dentistry, etc. Some are solid while others are liquid. Mercury can be distilled off from most amalgams by heating them in retorts. It is in this way that gold and silver are recovered from their amalgams.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

A pointer! "Don't point at anything electrical," admonishes the Rochester Ry. & Light Co. And there is a large illustration posted for its employees, showing how to point—away from the apparatus. Another pointer: Don't point at all!

"Made in America!" Can we make this slogan heard all over the world? Looks as though we could if our manufacturers and exporters properly steer the industrial boat instead of rocking it.

Three-thousand pound angels are being raised at the Exposition grounds—by a locomotive derrick having its boom extended by a 66-ft. spar to a radius of 106 ft. Even angels, bronze ones anyhow, are glad to have old man Steam give 'em a lift.

The Pennsylvania R.R. has 170 ranking officers, 163 of whom started in sweeping out, carrying water—doing chores. And 142 of these men have been over 20 years with the road. It pays to stick when the sticking is good. But pick a good place to stay stuck.

HORAN—There's an outrageous lot of liars these days, Dinny.

DORAN—True fer you, Hughey, an' 'tis passin' strange, bein' so widespread and apparently easy, that the art of lyin' is so far from perfection.

We were beginning to wonder if our old friend Tim Healy had been eclipsed by his duties as coroner, when up he bobs as a open-market committeeman and trying to teach the New York school children how to buy food and lessen the cost of living.

THAT PROUD MOMENT

Looking backward, and downward a couple of lines, remember the day your Lizzie came over to the plant, and

you showed her about? And you lugged around the oil can (as an emblem of authority, for you were only a kid then), and you pointed out the equipment, and told Lizzie what each part did—or what you thought it did, and 'twas all the same to Lizzie. Gee! but have you ever felt as big since? You bet you haven't, nor won't!

Power-Plant Report Sheets

By W. G. Webster

The report blanks, Figs. 1 and 2, are used by a large power system having several plants. They can be adopted by any power station producing electrical energy. Fig. 3 is a form of report sheet for producer-gas power plants which, by making a few changes, can also be used in any size plant.

The daily report sheet for the power station is applicable to almost any station generating electricity, either alternating, direct current or both. Space is provided

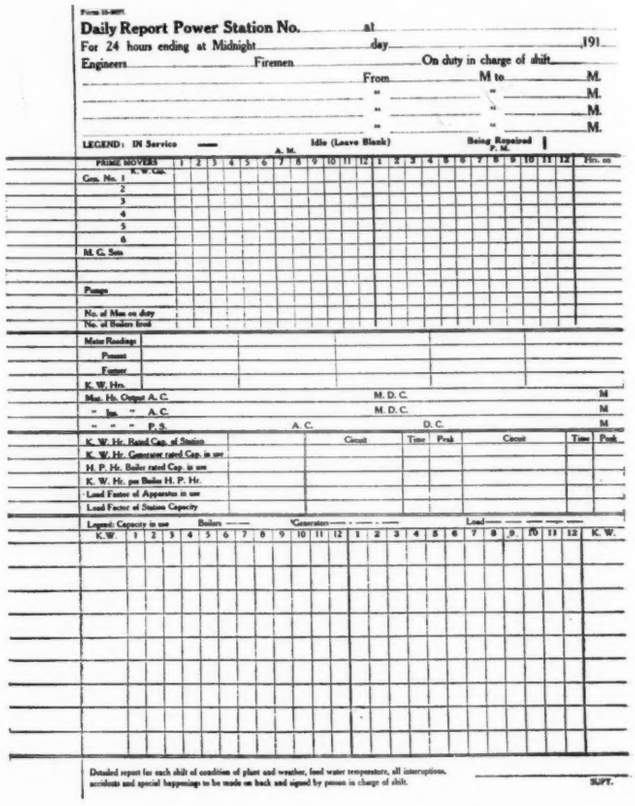


Fig. 1. Daily Report Sheet

for a record of the men on shift and when the shift changes, for recording the generating apparatus in service, and for the hour the units were in and out, thus making it easy to learn the period a machine was in service, and why it was taken off. When motor-generator sets or rotary converters are used, a record is had of the length of the run and the time on and off, regardless of the number of times they are started or stopped. Likewise, a record of the pumps or other apparatus is kept. The line representing the number of men on duty at any particular time is especially valuable. The record of boilers under steam or off or being repaired is also kept. The meter readings are of the output in kilowatt-hours for each unit during the twenty-four hours.

Maximum-hour output records are valuable, as they show the maximum-hour demand on the plant in kilowatts, and at what hours it occurred for both alternating-current and direct-current loads.

The kilowatt-hour rated capacity remains constant unless changes are made in adding to or taking out gen-

erating equipment. The kilowatt-hour generator capacity in use is found by the sum of the rated capacities of the units times the hours each was in service.

The rated horsepower-hour boiler capacity is obtained by the same method, and shows the relation between the kilowatt-hour generator capacity and the boiler-horsepower capacity. The kilowatt-hour per boiler-horsepower shows this relation in percentage.

The percentage of load factor of the apparatus is found by dividing the total kilowatt-hour output by the kilowatt-hours of the generator capacity in use. The load factor shows the load percentage of the station capacity; the remainder of the report is used to indicate that of the boiler-horsepower at any time during the day. The generator capacity is also recorded; the kilowatt-hour output is shown graphically. On the back of the report sheet are recorded the conditions, interruptions, etc.

The sheet may be extended at the top and holes punched for filing. An attractive sheet is made by using black for all the numerals, wording and vertical lines, and blue for the horizontal lines.

Space could well be provided, as in the Fig. 1 report sheet, for the total kilowatt-hours generated and for outdoor and indoor and feed-water temperature, vacuum or any other hourly reading.

Form 29—6-13-1M

Monthly Report No.____ Power Station _____ 191_

MAINTENANCE COSTS			OPERATING COSTS		
Buildings			Superintendency		
Boilers and Setting			Clerks		
Engines			Engineers		
Turbines			Oilers and Wipers		
Oil System			Switchb'd Att'ndts		
Pumps			Firemen		
Condensers			Unloading Coal		
Piping			Ash Handling		
Coal Hdlg. Machry.			Misc. Labor		
Misc. Steam Mchry.			Fuel		
Stokers and Arches			Water for Power		
Ash Hdlg. Machry.			Lubricants & Waste		
Generators			Misc. Sup. & Exp.		
Exciters			Print. & Stationery		
Switchboard & Wir			Misc. Office Exp.		
Transformers			Storeroom Exp.		
Misc. Electric Repr.			Misc. Gen. Exp.		
Regulators			Damages		
			Insurance		
			Engineering		
Total Maintenance			Total Operating		
			Total Cost		

SERVICE HOURS OF PRIME MOVERS AND BOILERS

Eng. Hrs. x K. W. K. W. Hrs. Boiler Hours

Meter Readings D. C. 60 Cycle

Present

Former

Difference

K. W. Hrs. = $

Coal Tons @ Per Ton = Total

On hand 1st of month

R. M. Rec'd during month

Slack

Total

On Hand Last Month

Consumed during month

Care of Coal on the Yard

Lbs. of Coal per K. W. Hr

per D° of Grate Surface

Ave. K. W. Hr. per Boiler H.P.

Operating load factor in %

Station " " "

Average load to peak

Maint. Cost per K. W. Hr.

Operating Cost per K. W. Hr.

Total Cost per K. W. Hr.

Max D. C. Load K. W. at

" 60 " " " "

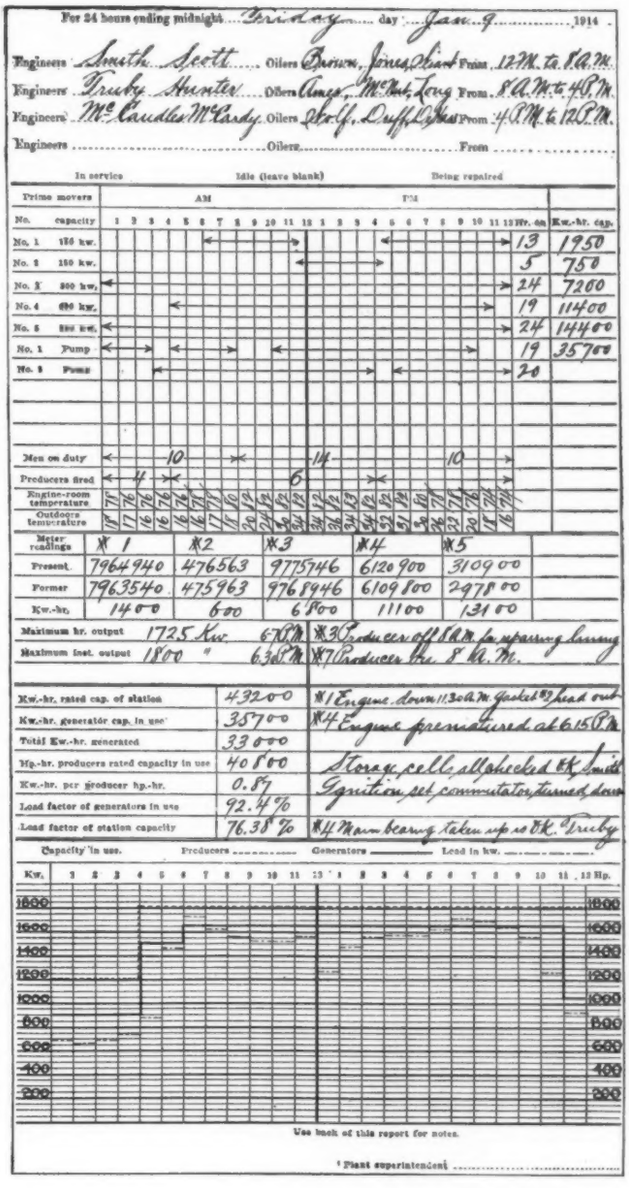
" Station " " "

Remarks: State in detail conditions of plant, special happenings, interruptions due Power Station, special repairs and construction work, progress of the same, etc.

Supt. Power. Supt. Plant.

FIG. 2. MONTHLY REPORT SHEET

The monthly report, Fig. 2, made up from the daily reports, is self-explanatory, and covers the main items of interest. When one keeps a record of plant operation, there is something to show when the central-station man comes around and tries to tell what he will do in the matter of cheap power.



For 24 hours ending midnight Friday day Jan. 9 1914

Engineers Smith, Scott Oilers Brown, Jones, Hart From 12 M. to 8 A. M.

Engineers Truby, Hunter Oilers Agnes, McPhail, Long From 8 A. M. to 4 P. M.

Engineers McCandless, McCurdy Oilers Geo. G. Duff, Lloyd From 4 P. M. to 12 P. M.

Engineers ..... Oilers ..... From .....

In service Idle (leave blank) Being repaired

Prime movers No.	capacity	Hr. on	Kw.-hr. cap.
No. 1	150 kw.	13	1950
No. 2	150 kw.	5	750
No. 3	300 kw.	24	7200
No. 4	600 kw.	19	11400
No. 5	600 kw.	24	14400
No. 1	Pump	19	35700
No. 2	Pump	20	

Men on duty 10 14 10

Producers fired 4 6

Meter readings	#1	#2	#3	#4	#5
Present	7964940	476563	9775946	6120900	3109000
Former	7963540	475963	9768946	6109800	2978500
Kw.-hr.	1400	600	6900	11100	130100

Maximum hr. output 1725 Kw. 6 P.M. #3 Producer off 8 A.M. for spring lining

Maximum inst. output 1800 " 6:35 P.M. #7 Producer fire 8 A. M.

Kw.-hr. rated cap. of station	43200	#1 Engine down 11:30 A.M. Gasket blo'd head out
Kw.-hr. generator cap. in use	35700	#4 Engine prematured at 6:15 P.M.
Total Kw.-hr. generated	33000	
Hp.-hr. producers rated capacity in use	40800	Storage cells all checked OK Smith
Kw.-hr. per producer hp.-hr.	0.89	Ignition set, commutator turned down
Load factor of generators in use	92.4%	
Load factor of station capacity	76.38%	#4 Main bearing taken up 10 OK Truby

Capacity in use. Producers ..... Generators ..... Load in kw. .....

Kw. 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 Hp.

1800 1600 1400 1200 1000 800 600 400 200

Use back of this report for notes.

Plant superintendent .....

FIG. 3. REPORT SHEET FOR PRODUCER GAS PLANT

Safeguards around Machinery

Suitable guards should be placed around all moving parts of machinery with which an attendant or workman is liable to come in contact and receive injury. In some cases a revolving shaft is not considered dangerous until some one in injured, and such accidents are numerous.

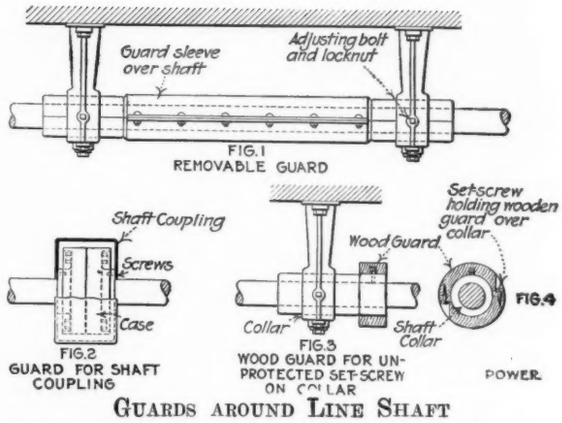
In a manufacturing plant recently visited, it was surprising to find that all the shafting had removable guards between the hangers, as illustrated in Fig. 1. Some were cast iron and others of considerable length were heavy sheet iron, made in halves and bolted togther at the flanges on the sides; they were attached to the bearings with screws.

Wooden collars were placed on the inside, surrounding but not touching the shaft, so that the guard can not be bent in against the shaft. Fig. 2 is a guard over a shaft

coupling and is attached to it by screws, and revolves with the shaft, but as the outside surface is smooth, there is but little chance for clothing to catch on it.

A better way would be to have the guard made large enough to clear the coupling and attach it to the end of the bearing. The end of the guard next to a pulley can be supported by a screen guard by the side of the pulley, which will also guard the attendants from the pulley and belts. Where belts or ropes pass through floors or rooms they should be boxed in. Sufficient space should be allowed between two pulleys for the belt to lay flat, should it come off, to prevent its becoming entangled and break the belt or pull down the shafting.

A belt hook should be made on which to hang the belt when not in use, as it will be badly worn if allowed to hang on a revolving shaft. All keys or feathers should be covered with a guard. Unprotected setscrews on collars can be covered with a wooden guard, Fig. 3, made in halves and clamped together by screws. Fig. 4 is an end view of Fig. 3.



GUARDS AROUND LINE SHAFT

Power-Plant Economies*

SYNOPSIS—General conditions affecting economical operation of the electrical and mechanical equipment of an office building.

Primarily, the building manager is responsible for the power plant if he has full power, and the operating engineer, who is directly in charge of the engineering equipment of the building, is responsible to the manager for its satisfactory operation. This phase of the manager's responsibility is important, because the difference between first-class and careless or indifferent operation by the engineering department may amount to thousands of dollars each year. In either case, it constitutes a gain or loss which is invisible to anyone not thoroughly trained in operating engineering, unless by comparison with previous years. A manager knows the amount of soap or labor required to properly clean 1000 sq.ft. of floor area in his building, but in how many instances does he know the pounds of steam which should be required in the building per month? To a considerable extent, he is dependent upon the honesty and capability of the operating engineer, because a building manager is not required or expected to have a thorough knowledge of engineering. It is therefore his duty to select an engineer who will operate the plant at maximum efficiency.

The field from which a selection might be made is broad and, not infrequently, the choice is unfortunate. The manager does not become aware of his error unless possibly by comparison with the records of previous or subsequent occupants of the same position. The man selected should have a proved record for honesty and engineering ability, and if these qualifications are not known to the manager, a method of inquiry might be adopted similar but more searching than that employed when determining the financial responsibility and general reputation of a prospective tenant. An irresponsible tenant may possibly cost the building a month's rent, while an incompetent engineer may cause a loss many times greater before being detected. Clean records in engineering, like those of business, will bear the closest examination, and the man whose experience proves him capable of successful economical management of a building's engineering equipment is reasonably certain to operate another plant similarly.

With the constant increase in the size of the modern skyscraper there is a corresponding increase in the size and complexity of the engineering equipment, which it is reasonable to suppose should require a similar degree of increase in skill and ability on the part of the man who is engaged to operate the plant. Other qualifications of no less importance than experience and education, which must be possessed by a successful engineer, are the ability to properly handle men and a reputation for honesty.

The measures to be adopted in the selection of such an engineer are rarely ever followed, it being considered unnecessary to do more than to fix a price, which is often too low, and induce some applicant to accept after a brief examination of his record. This is a chance method and the results are naturally problematical. Occasionally it so happens that an employer takes an engineer purely on a price basis and suffers accordingly. He alone is at fault, not the engineer, regardless of what the results may be, inasmuch as he has placed a premium on dishonesty and inefficiency.

In any successful manufacturing enterprise of today requiring labor, machinery and materials, the utmost care and attention are given by experts in this particular line to the proper construction of the building which is to house the industry; to the selection of the machinery best adapted to the requirements and to its proper arrangement to avoid unnecessary handling of materials, minimizing the labor.

The engineering equipment of a modern building is not generally looked upon as a manufacturing establishment. In the final analysis it is just this, and nothing more. The raw materials are coal, or other combustible, air and water, the finished products being light, heat and power in various forms according to the requirements of the building.

Eliminating operation, the ultimate degree of economy of the building power plant, like its parallel the manufacturing establishment, is dependent upon proper housing of the machinery and appliances; the selection of the kind, type and sizes of machines best adapted to meet the requirements and upon such arrangement of this equipment as will reduce the labor.

Owners and managers should realize that the space allotted to the machinery of the power plant has an appreciable effect on the efficiency at which it can be made to operate. It is of necessity usually at or near the lowest level of the building and, in many instances, to reduce the cost of excavation, the space is crowded and lacks sufficient head room. The boiler room is frequently so proportioned that the piping and valves overhead are cramped against the ceiling so closely that it is impossible to work in this space without physical discomfort.

Often the safety valves are attached to the ends of the boiler drums and depressions made in the ceiling to permit removal of the caps. The men are required to work over the boilers in a temperature around 150 deg., crawling over or under hot pipes, and the tools must be handled with gloves to prevent burning the flesh. If those responsible for these conditions were compelled to endure them for a short time, the working space over and around boilers would be much more habitable in the near future, regardless of the additional cost of excavation. It is generally recognized that better work is accomplished under reasonably comfortable conditions, so that, in the interest of maintenance and economical operation, attention should be given to making habitable the space housing the power manufacturing equipment and of such character as to cause an almost unconscious incentive for neat, clean conditions.

To secure the highest degree of economy in operation there are certain sizes and types of machines and appliances

*Abstract of a paper read by F. K. Boomhower before the National Association of Building Owners and Managers, Duluth, Minn., July 15.

best adapted to the needs. The selection of the proper equipment calls for men of experience and training. Here the owner's or manager's responsibility is again involved, for he must choose the man who is to select the power-plant equipment.

After reaching the decision to erect a building on a certain location, the usual course of procedure is to engage an architect who is told the type of building desired and the amount of money available for this purpose. He proceeds to design a building to meet the approval of the owner, which when completed shall not exceed the amount appropriated and still be a credit to the owner as well as an example of the skill of the architect. This is a commendable ambition and one to which no objection may be raised were it not for the fact that the architect is rarely a good engineer. In his struggle to obtain as much building as possible for the amount of money at his command, he often subordinates vital features of the engineering equipment to structural details or architectural design—in other words, he places æsthetics before engineering.

Nearly all architects have their own engineering departments, which enables them to handle the building and its equipment complete throughout construction. Naturally, this department is largely dominated by the architectural end, and when deciding on the final plans and specifications, the cost to fall within fixed limits, the engineers are called upon to make the greater percentage of reduction.

FALSE ECONOMY

This often leads to a corresponding reduction in the economy of operation, because such reductions must be made largely by the use of lower-grade machinery and appliances. For example, take the item of gate or globe valves used on steam and water lines. A valve of certain size may be purchased for $1.98; another grade of the same size and working pressure may cost $5. To many owners, managers and architects they appear very similar. They are of the same color, the same general shape, are built for the same purpose, and they cannot understand why the cheaper valve is not practically the equal of the more expensive one for their particular purpose. If, however, these gentlemen were asked why they do not wear a pair of $1.98 shoes in place of a $5 or $6 pair, they could readily explain, yet both pairs are of the same color, the same shape, the same general appearance and for the same purpose. This inability to appreciate the difference in the value of the valves is due, of course, to a lack of experience in work involving the handling and maintenance of this equipment. To the engineer who is familiar with this line of work, the relative values are easily perceptible, though difficult to explain to anyone untrained in this direction, especially if unwilling to be convinced, as when a reduction of initial cost of installation is involved.

Another feature of importance rarely mentioned in specifications is the packing on high-pressure gate and globe valve stems. These are usually packed by the manufacturer with the cheapest kind of material; if not, the contractor proceeds to do the work with a similar material. Neither of these men is at fault because he is not required by the terms of contract or specifications to do otherwise. Flange joint packing may be purchased as low as 30c. per lb., while a first-class article will cost around $1.15 per lb. In a comparatively short time the joints must be renewed at a cost much greater than the price of the original defective gasket.

A similar omission is the failure to require all pump valve stems and other small rods to be provided with a packing known to be satisfactory and durable. These matters are not usually thought of sufficient importance for serious consideration, but in a plant packed in an indifferent manner the operating engineer must soon do the work which should have been cared for in the specifications.

TYPE OF ENGINE

The original cost of the power plant equipment may be reduced by installing high-speed engines instead of the moderate or slow-speed type, and without appreciable change of economy in the use of steam. This step carries with it a corresponding decrease in the cost of generators in the case of direct-connected units. No special objection can be raised except that from an operating standpoint the engineer who has handled both the high- and moderate- or slow-speed types is almost invariably an advocate of slow speed, because he knows this type is more easily operated and gives less trouble. The oldest engines in successful operation today are in the slow-speed class.

It may be said with much truth that the present tendency is toward higher speeds, but this should be charged to competition rather than to increased economy and life. Then owners and managers have discovered that the higher the speed of any given size of unit the less the floor space required and consequently less excavation and concrete and more space is available for some other purpose.

Engines are usually required by specification to operate at a minimum steam consumption, are nickel trimmed, equipped with all the necessary extras and finished in a fancy coat of paint. Working alongside these same engines are steam-driven auxiliaries in the form of pumps frequently outnumbering the engines two to one and struggling along often at too high a speed, blowing steam to the four winds and leaking in the valves and stuffing-boxes. The specifications would have been quite as effective had they simply called for some iron castings bored full of holes, fastened together with machine steel rods and studs with hot-punched nuts to resemble the general form of a pump. There are certain conditions under which it would be unwise to require these auxiliaries to be of the highest possible grade, as, for example, when the exhaust may be used for heating. Under this condition, why should the engine be required to work to the last ounce of steam? In nearly all power plants, steam-driven pumps are worthy of more consideration than is usually allotted them by those responsible for the original installation.

The possibilities and results of reducing the cost of a power plant to a minimum are briefly indicated by the preceding, and although a volume of considerable size might be devoted to a discussion of relative values of the different machines and appliances, enough has been said to show that this subject requires and should receive careful treatment by competent men, and that it is for the best interests of the owner or manager to lend his support to the one whom he has selected to decide upon what shall be installed.

BOILER ROOM LAYOUT

Another feature of the original installation having an important bearing on economy is the arrangement of the various parts. The boiler rooms of practically all buildings of the type under consideration are on the lowest level. Coal in most cases may be delivered at grade and, in addition, is sometimes received from a tunnel or subway. By a careful study of the situation the boilers and coal bunkers may be so placed that the coal will be carried by gravity from the delivery truck to the furnaces without any labor, power or machinery other than a traveling coal weigher. Coal-handling machinery is expensive, and a constant source of trouble and expense to operate. In the majority of office-building or hotel plants, this equipment is unnecessary unless coal is taken from a level below the bunkers. Occasionally it is impossible to obtain such a layout due to insufficient depth from grade to the boiler-room floor, the headroom being limited on account of the additional cost of excavation, retaining wall and footings. Owners and managers should remember that after installation the only expense attached to this additional cost is an annual 4 or 5 per cent., while with the alternative, is the original cost of installation with its 4 or 5 per cent., power to operate, labor, repairs and depreciation.

The proper arrangement and selection of ash-handling machinery is usually a difficult problem in plants which are below grade, because the ashes must be collected from beneath the various furnaces and delivered to a bunker or wagon at ground level. Where it is possible to deliver to a tunnel below the boilers, the operation becomes simple. Each building presents a different set of conditions which must be skillfully treated to obtain a durable operating system, but there can exist no satisfactory reason from an engineering standpoint for the clumsy ways coal and ashes are handled in some buildings.

THE AIR SUPPLY

Another of the raw materials necessary for the manufacture of power is the oxygen which is obtained from the air. It is free and just as essential as coal or water, yet often proper provision for feeding the furnaces with this material is not made. The fires are partially choked, receiving air by accident rather than design. The accident is in the form of a stack, which must of necessity extend above the building, thereby creating sufficient draft to overcome the resistance offered to the air flowing to the furnaces through doors, windows and other openings.

The general impression among those who have not studied the subject is that the fires do not require much air; that it is unnecessary to give any consideration to this point. Just how trifling the question is may be learned when it becomes known that to burn coal at the rate of 40 tons per 24 hr. usually requires in round numbers 18,000 cu.ft. of air per min. This may account for the strong draft in the openings leading to some boiler rooms.

A part of this air at least, and in some cases all of it, should be forced in by fans or permitted to flow free from the exterior of the building to the engine room through special ducts, and from there to the boiler room. In some cases the exhausting power of the stack may be sufficient to provide the necessary air change, but in no case should the boiler room be under less than atmospheric pressure.

Engineers familiar with power-plant operation are aware that the owner of a plant containing inferior equipment ultimately pays more than the price of a first-class installation. As they are just as desirous of accomplishing work which will be a credit to their ability as is the architect, and it is to be regretted that owners and managers are usually not as capable of judging engineering features as architecture. The economical operation of a building involves real engineering, and ability and experience are required. If the manager adopts the suggestions given in selecting the man who is to install or operate the plant, and grants him proper support, economical operation will be insured.

Cooling Effect of Evaporation

An interesting experiment may be easily performed to demonstrate the cooling effect by evaporation, in the following manner:

Take a watch glass or any other wide and shallow receptacle of thin material, set it in a depression in a cork containing a few drops of water, then fill the watch glass about half full of ether. By directing a steady current of air through a tube or straw on the surface of the ether, its evaporation will be so rapid that the water will be frozen in a short time.

The reason is, that whenever a vessel is only partly filled with a liquid, the remainder of the vessel always contains some of the substance in a gaseous form called vapor. The rate at which evaporation proceeds depends largely upon the amount of vapor already present over the liquid.

If the vessel is closed, it is found that at any one temperature, evaporation will continue until the vapor exerts a certain pressure on the surface of the liquid, known as the vapor tension at that temperature. Evaporation does not cease, however, but rather condensation equals evaporation.

Therefore, dispersing the vapor by a jet of air, or removing the pressure over the fluid by a vacuum pump and extending the area of the surface exposed to such action, tends to increase the evaporation and cooling effect.

Regulation on 150,000-Volt Line

In a paper read at the Pacific coast meeting of the American Institute of Electrical Engineers, Sept. 9 to 11, Edward Woodbury gave an interesting account of the regulation employed on the transmission system of the Big Creek Development of the Pacific Light & Power Corporation.

This development, it will be recalled, employs the highest transmission voltage yet attempted, namely, 150,000 volts, the distance to Los Angeles being 240 miles. A total head of 4000 ft. is utilized in two steps, about 4½ miles apart, each of the power houses at present containing two 17,500-kv.a. generating units.

The inherent regulation of the transmission line alone, without terminal equipment, is from 10 per cent. above power house voltage at no load to 20 per cent. below at full load;

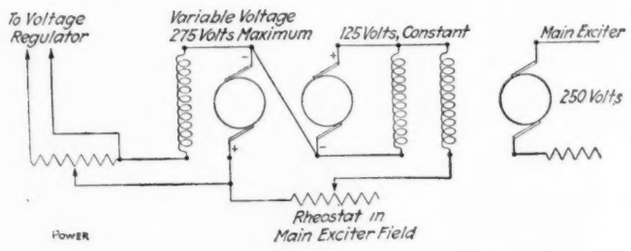


FIG. 1. METHOD OF CONTROL IN PLANT NO. 1

and the effect of the transformer inductive reactance at the generating end practically doubles the boosting at light load. Also, the self-exciting characteristics of the generators, when supplying charging current only, tend to produce abnormal voltages at no load.

A constant potential system is maintained by the use of two 15,000-kv.a. synchronous condensers at the receiving end and automatic voltage regulators, one for each generator and each condenser.

In one of the generating stations, the excitation system consists of three units, the main exciter and two auxiliary exciters, the latter connected in series opposition, as indicated in Fig. 1. The auxiliary units excite the field of the main exciter and are designed to generate at 125 to 275 volts, respectively. With a potential regulator on the 275-volt

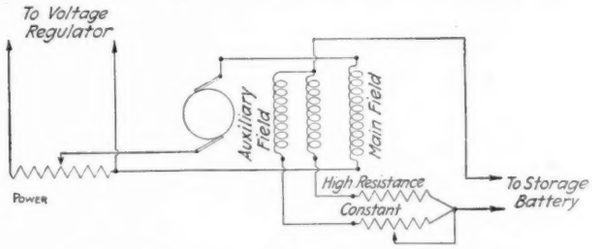


FIG. 2. METHOD OF CONTROL IN PLANT NO. 2

machine arranged to prevent a reversal of the field in the 125-volt set, the voltage applied to the exciter field may be changed from that required to give maximum excitation to zero excitation.

At the other station, the generators are excited directly by 200-kw., 250-volt exciters, the main fields of which are controlled by a new type of alternating-current automatic voltage regulator, which has no direct-current magnet and which can therefore be adjusted to reduce the exciter voltage to zero. The exciters on this system have three shunt windings on the field, as shown in Fig. 2. One auxiliary field is provided to give the reversed excitation necessary to hold the voltage down when charging the line, the current being supplied to this field, through a variable resistance, by means of a storage battery. The other auxiliary field, which is solely for the purpose of maintaining the correct polarity, also takes its current, which is small, from the same storage battery.

A reduction of the excitation to zero by means of the potential regulator has not been necessary at the generating stations, but operation of the synchronous condensers at the receiving station, over the range required, would not be feasible without a complete reduction of the exciter voltage.

With 150,000 volts at the receiving end of the line, the charging current is about 10 per cent. overload for one generator. With normal voltage of 6600 volts at the generator, the charging current overloads the generator 65 to 70 per cent. Hence, in normal operation, a line is usually energized by using two generators, under which condition a small field excitation in the normal direction is required. Abnormal conditions sometimes make it necessary to charge the line from a single generator, until the condensers at the receiving station can be started.

The self-exciting characteristics of the system with leading current are such that in one of the generating stations a single 6600-volt generator, when connected to an unloaded line without its condenser and run at normal speed with the field switch open, would excite itself to 7000 volts, corresponding to 176,000 volts on the transmission line at the generating station, and demand from the generators 34,000 kv.a. and 850 actual kw.

Many European Nations at Panama Exposition

In answer to numerous inquiries, President Charles C. Moore of the Panama-Pacific International Exposition, to open in San Francisco on Feb. 20, 1915, has issued the following statement:

One month ago, the decision of the Panama-Pacific International Exposition management not to postpone was first published. The development of events since then in their relation to the exposition all tend to confirm the wisdom of that original decision.

At the time the decision was made no word had been received from any foreign nation as to the effect on its plans caused by the European war, but it was hoped that at least those nations not fighting would go on with their plans. Later developments have proved that hope well founded; in addition, we have definite assurances from France, Italy, Turkey and Japan that their intentions are unchanged. Holland has added $300,000 to her original appropriation, Italy has ordered work on her building and exhibits rushed, Japan has asked for and received an increase of space, and the

Argentine Republic has increased its appropriation from $1,250,000 to $1,750,000.

We shall undoubtedly lose some of the promised exhibits from Europe, but not by any means all of them nor the most important of them. Both Germany and Great Britain will be represented by individual exhibitors or by associations thereof. We shall undoubtedly lose some of the promised entries by European champions in the athletic events, but the international character of those events will not be lost. We may lose some of the art treasures promised us for the Fire Arts Building, but we shall gain others because of the war.

Of compensating gains we have many. There is a very sharp demand for space from the manufacturers of this country, of South America and of the European nations not at war. The exposition suddenly becomes an important factor in an extraordinary economic situation. It is seen to be the one, great, easy, efficient way by which American made goods can be brought to the direct attention of the distributors and consumers of South America and the Orient. The latter are coming here in force in 1915 to make the new individual and commercial connections forced by the war.

As regards attendance, every transportation expert confirms the opinion that a continued European war is likely rather to increase travel to California in 1915 than to reduce it.

The exposition is 92 per cent. ready today. It will open Feb. 20, as planned, and it will be the most beautiful and most interesting exposition ever seen. There is no reason to believe that its success, in any phase, will be any less than that which was so certain before the European war broke out and it is certain to be even more important commercially than was ever dreamed.

Boiler Makers Meet to Forward Adoption of Uniform Boiler Laws

On Tuesday, Sept. 29, about sixty representatives of the largest and most important boiler manufacturing interests of the United States met at Pittsburgh to formulate plans and initiate activities to bring about the adoption by the various states of laws putting into effect the Code of Boiler Rules, which the committee appointed for that purpose will report to the fall meeting of the American Society of Mechanical Engineers.

An executive committee consisting of Thomas E. Durban, of the Erie City Iron Works, representing the fire-tube, Isaac Harter, Jr., of the Babcock & Wilcox Co., representing the water-tube, and A. B. Goodling, of the A. B. Farquhar Co., Ltd., the traction and agricultural boiler interests, was appointed to represent the boiler manufacturers in conference with the American Society of Mechanical Engineers committee and to direct the efforts of the boiler makers toward bringing the code into use. Abundant financial support was assured.

Industrial Education

The National Association of Corporation Schools has received a report from its subcommittee on the scope of activities for 1914 and 1915, which was adopted by the executive committee, Sept. 1, 1914. When the recommendations in this report are carried into effect, the association will have syllabi of courses to send to corporations asking for data as to the subjects to be taught.

The committee on safety, hygiene and coöperation will distribute printed matter in the shape of summaries of the work in safety and hygiene in industrial corporations, and make recommendations as to instruction along those lines.

The association also purposes to prepare bibliographies on the subject of service annuities, profit-sharing plans, sick and death benefits and savings funds.

The committee on public education is to investigate and ascertain to what extent the industries are at present cooperating with public schools in the various cities and to make a compilation of the experiences of the industrial corporations which have coöperated with the public-school systems. Further, it is to show in what additional ways the two may coöperate, and special attention will be given to collecting data regarding general educational courses in which the experience of industries has shown the public schools to be particularly weak, with reference to fitting a person to enter industrial life. Finally, the committee is to ascertain to what extent the industries find it necessary to duplicate the educational work of the public schools, and if possible investigate in several localities to find out whether the public schools are willing to conduct courses for or in connection with the industries to supply this inefficiency.

The committee on allied institutions will compile names of all organizations which include in their activities, or are contemplating doing so, the study of industrial educational work, learning the policy and scope of each of these institutions, making recommendations to the executive committee as to the ways in which the association can coöperate with these organizations, and to establish relations with the Librarians' Association with a view to having a selected list of books and industrial subjects placed in public libraries.

A new committee, to be known as the committee on employment plans and allied subjects, is to be formed which will take up the subject of employment with the allied topics of vocational guidance, promotion, discipline, physical examination, etc.

The several different committees on special schools, including trade apprenticeship, special apprenticeship, accounting and office work, advertising, selling and distribution, will prepare general syllabi that may be made a basis for courses by corporations desiring to undertake educational work for their employees. Both special and general subjects will be taught. Which general subjects should be included, however, must be determined by each corporation in accordance with the extent to which their new employees have been properly prepared in the public schools. It is recommended that each of the four committees should make a compilation of the work of at least a representative number of large corporations which are conducting educational work on behalf of their employees. The best compilation should include results which have been obtained. Finally, each committee is to look into the activities of such institutions as the Alexander Hamilton Institute, the International Correspondence Schools and the Sheldon School, to determine to what extent the work of these institutions can be used profitably by the corporation schools.

The executive committee, in approving the report, will put on foot a piece of splendid work for the betterment of conditions among those now engaged and soon to be engaged in the various industries. It is a work deserving of a great deal of attention and the hearty coöperation of all corporations. The report was signed by G. B. Everitt, F. C. Henderschott and E. J. Mehren, chairman.

Tube Failure Interrupts Service

Due to a series of tube failures in three boilers at the Livingston plant of the Richmond Light & Railroad Co., on Saturday afternoon, Sept. 26, trolley service on Staten Island, N. Y., was completely held up for over an hour and the lighting and commercial service for about seven hours. Moreover, two of the engineers were painfully scalded by the steam and water from the first tube which opened up.

The boilers, which were temporarily put out of service are practically new ones of the B. & W. type and the tubes were seamless drawn steel. The complete tieup of service was brought about by an unfortunate combination of circumstances. Aside from the tube failures in three boilers within a short period, two new boilers which have just been added were not yet ready for service and four of the old boilers, which were held in reserve, are allowed only 130 pounds pressure as against 200 pounds on the new boilers. With this reduced pressure it was difficult to keep the turbine auxiliaries up to speed and thus hold the load on the turbines.

PERSONALS

H. V. Neff, chairman of the Ohio Board of Boiler Rules, was present at the hearing of the A. S. M. E. committee of uniform boiler laws with two other members of the Board and testified to the interest of that body in the work upon which the committee is engaged.

OBITUARY

FRANK BAER

In attempting to remove a live wire that had dropped into Pennsylvania Ave., Frank Baer, 40 years old, superintendent of the Kutztown Electric Co., was instantly killed on Sept. 24, at Kutztown, Penn. During a heavy shower, the

wire was blown down. Mr. Baer was attending a church meeting at Grace United Evangelical Church, where he was notified of the accident. He hurried to the scene with insulated pliers, but as he touched the wire the pliers were knocked from his hands and he was hurled to the ground. Word was sent to the plant and the power was turned off.

Baer was removed to a nearby porch, where physicians said death was instantaneous.

TRADE CATALOGS

McCord Mfg. Co., Detroit, Mich. Catalog. Force feed lubricators. Illustrated, 30 pp., 6x9 in.

The Vilter Mfg. Co., Milwaukee, Wis. Catalog. Corliss engines. Illustrated, 40 pp., 7x10 in.

John O'Brien Boiler Works Co., St. Louis, Mo. Pamphlet. O'Brien-Hawley down-draft system of smokeless combustion. Illustrated, 12 pp., 6x9 in.

The Lagonda Mfg. Co., Springfield, Ohio. Catalog R-2. Multiple strainers. Illustrated, 20 pp., 7½x10 in.

Ingersoll-Rand Co., 11 Broadway, New York. Form No. 3024. Ingersoll-Rogler valves for air compressing cylinders. Illustrated, 28 pp., 6x9 in. Form No. 3030. Class ER-1 Ingersoll-Rogler air compressors. Illustrated, 20 pp., 6x9 in.

Coen Company, San Francisco, Cal., Catalog. Fuel oil burners. Illustrated, 32 pp., 8x11 in.

National Tube Co., Pittsburgh, Penn. Bulletin No. 7D. Regrinding valves. Illustrated, 8 pp., 8½x11 in.

Smooth-On Mfg. Co., 572-74 Communipaw Ave., Jersey City, N. J. Smooth-On Instruction Book No. 15. Iron cements, iron paints and corrugated iron gaskets. Illustrated, 104 pp., 4½x6½ in.

Essex Rubber Co., Trenton, N. J. Catalog K. Packings. Illustrated, 50 pp., 6x9 in.

The Industrial Instrument Co., Foxboro, Mass. Bulletin No. 82. Liquid level gages. Illustrated, 20 pp., 8x11 in. Bulletin No. 88. Recording gages. Illustrated, 32 pp., 8x11 in.

National Tube Co., Pittsburgh, Penn. Bulletin No. 9C. Some tests of Kewanee unions. Illustrated, 8 pp., 8½x11 in.

The Hill Clutch Co., Cleveland, Ohio. Catalog No. 11. Power transmission machinery. Illustrated, 224 pp., 6x9 in.

The Engineers Appliance Co., Cleveland, Ohio. Catalog No. 3A. Hydromatic valves, steam traps, low pressure water feeder. Illustrated, 20 pp., 6x9 in.

Tate, Jones & Co., Inc., Pittsburgh, Penn. Catalog. Appliances for burning fuel oil. Illustrated, 32 pp., 8½x11 in.

Armstrong Cork & Insulation Co., Pittsburgh, Penn. Booklet. Nonpareil insulating brick for boiler settings. Illustrated, 3½x6 in.

Moffat Feed Water Heater and Purifier Co., Detroit, Mich. Catalog. Combined feed water heaters, purifiers and oil extractors. Illustrated, 24 pp., 6x9 in.

Gifford-Wood Co., Hudson, N. Y. Catalog. Ice and coal handling machinery. Illustrated, 180 pp., 6½x10 in.

BUSINESS ITEMS

L. J. Wing Manufacturing Co., Ninth Ave. and 14th St., New York has just issued Bulletin No. 28 which illustrates and fully describes the Wing Fans. Copies are sent on request.

It is interesting to note that the sales of the Northern Equipment Co., Erie, Penn., were practically doubled within the past year—and to take care of the rapidly increasing business the company has purchased the shops formerly occupied by the Olds Pump Works of Erie, Penn. Two new sales agencies have also been added—Scholey and Company, Ltd., 151 Queen Victoria St., London, Eng. and Thermal Efficiency Co., 716 Finance Bldg., Kansas City, Mo.

The C. & G. Cooper Company, Engine Builders, Mt. Vernon, Ohio, have had good business for August in their steam and gas engine departments. Among orders received is one from the Medina Gas & Fuel Co. for a 950 brake-horsepower twin tandem gas engine driven compressor, to be installed in the Mansfield, Ohio, station. This will be the third Cooper unit in the plant. The Ohio Fuel Supply Co. have also ordered three 475 b.-hp. single tandem gas engine driven compressors, to be installed in their Perrysville, Ohio, plant.

The Lagonda Manufacturing Co., of Springfield, Ohio, has just published a complete 20-page catalog descriptive of their Multiple Water Strainers for power plant and pumping station intake lines. These strainers are of the multiple straining basket type which can be easily and quickly cleaned without interruption to the flow of water. The new catalog is entitled "The Lagonda Multiple Strainer," edition R-2, and will be sent upon request.

The American Engineering Co., Philadelphia, Penn., has just published a new book on the Taylor stoker, which every man interested in the subject should have. Page after page of excellent illustrations of installations, complete details of construction and operation, several pages of names of Taylor stoker users. It is a handsomely prepared catalog, well worth reading, and is sent free on request.

Elliott Co., Pittsburgh, Penn., has appointed William A. Day Chicago district sales manager. Mr. Day was formerly sales manager of the Erie City Iron Works in the Chicago district, and is not only well known as a salesman, but as an engineer as well. The Elliott Co.'s Chicago office, in charge of Mr. Day, will be as heretofore, at 527 Monadnock Block.

Elliott Co., Pittsburgh, Penn., has appointed Mr. George Gray, of Boston, Mass., sales manager for the New England district. Mr. Gray is well known in the New England territory, and was connected with the Elliott Co.'s interests several years ago. The office of the company, in charge of Mr. Gray, will remain at 954 Oliver Building, Boston, as heretofore.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Germania Mills, Holyoke, Mass., will construct a power house, 60x100 ft. with an ell.

The Bon Ami Co., Manchester, Conn., manufacturer of cleaning compounds, has bought a site near its present plant and will make extensions, the first of which will be a power plant of sufficient capacity to supply the plant for some years to come.

George C. and Arthur M. Morgan, Engrs., 111 West Monroe St., Chicago, Ill., have been engaged by the City Council of Kittanning, Penn., to prepare plans for the installation of a municipal electric-light plant and water work. The estimated cost is $125,000.

Roth & Co., Denlka Bldg., Philadelphia, Penn., are preparing plans for the construction of a municipal electric-light plant for the Borough of Lewiston, Penn.

It is reported that the Mauch Chunk Heat, Power & Electric Light Co., Mauch Chunk, Penn., has purchased a site and will build a new substation.

SOUTHERN STATES

Press reports state that the city of Jacksonville, Fla., will install a 5000-kw. engine, to cost $60,000, in the municipal electric-light plant. W. H. Tucker is Supt.

Bonds for $10,000 were voted by the citizens of Pablo Beach, Fla., at a recent election, by the proceeds of which will be used for the construction of a municipal electric-light plant. The J. B. McCrary Co., Atlanta, Ga., is the Engr.

Bids will be received until Oct. 6, by the Mayor, Melville, La., for the installation of an electric-light plant.

The Bluegrass Motion Picture Mfg. Co., Glenarm, Ky., is in the market for generators, motors, etc., for a factory which it is equipping. George H. Kendrick is Mgr.

The Greensburg Loose Leaf Tobacco Warehouse Co., Greensburg, Ky., is in the market for power equipment for its prizing rooms.

At the November election the citizens of Princeton, Ky., will vote on the proposition of issuing $15,000 in bonds the proceeds of which will be used for the construction of a municipal electrci-light plant.

CENTRAL STATES

Bids will soon be received by Walter G. Franz, Union Trust Bldg., Cincinnati, Ohio, for a heating system for the isolation hospital to be erected by Cincinnati.

Bids will soon be received by W. A. DeVoss, Portsmouth, Ohio, for the installation of heating equipment in the new municipal school.

Press reports state that the Urbana Light Co., Urbana, Ohio, will enlarge its power plant. The company has obtained the contract for furnishing light to Woodstock, Ohio.

The Veedersburg Power Co., Veedersburg, Ind., has increased its capital stock from $100,000 to $125,000. Extensions will be made.

The Detroit Lumber Co., Detroit, Mich., will build a power house and garage costing $15,000.

Hiram Phillips, Consult. Engr., Third National Bank Bldg., St. Louis, Mo., has been retained by the Council of Sullivan, Ill., to prepare plans for the establishment of a municipal electric-light plant.

WEST OF MISSISSIPPI

Bonds in the amount of $7000 have been voted by the citizens of Aurelia, Iowa, the proceeds of which will be used for the construction of a municipal electric-light system.

The municipal power plant at Buhl, Minn., will be improved at an estimated cost of $50,000. Bonds for this purpose have been voted.

Bids will be received by the City Council, Lincoln, Neb., until Oct. 15, for making improvements to the electric-light plant and water system. Theodore H. Berg is City Clk.

Shade & Levesconte, Malta, Mont., contemplate installing an electric-light plant at Malta.

Improvements costing $17,000 to the electric light have been authorized by the Board of Aldermen, Kirkwood, Mo. The Board of Public Improvements will have charge of the work.

CANADA

The City Council, Quebec, Que., has authorized the construction of a boiler room on Beauport Road, estimated to cost $150,000. J. L. Pinsonnault, City Hall, is the Arch.

Press reports state that the United Gas & Fuel Co., Hamilton, Ont., will construct a coke and gas plant estimated to cost $1,500,000.

H. J. Glaubitz, Engr. Water-Works, London, Ont., is in the market for two waterwheels, turbine, pumps and motors.